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METROPOLITAN WATER BOARD

FIFTH ANNUAL REPORT



JANUARY 1, 1899

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WACHUSETT AQUEDUCT — CONDUIT CROSSING ASSABET RIVER ON BRIDGE (COMPLETED).

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FIFTH ANNUAL REPORT

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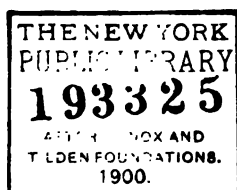
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METROPOLITAN WATER BOARD.

*To the Honorable the Senate and House of Representatives of the Commonwealth of
Massachusetts in General Court assembled.*

The Metropolitan Water Board, established under the provisions of chapter 488 of the Acts of the year 1895, respectfully submits its

FIFTH ANNUAL REPORT,

being a report of the work and operations of the Board for the year 1899.

I. ORGANIZATION:

(1) ADMINISTRATION.

Wilmot R. Evans, whose term of service expired, was reappointed a member of the Board for the term of three years, beginning with the first Monday in May, 1899; and the Board has continued as follows: Henry H. Sprague, chairman, Wilmot R. Evans and Henry P. Walcott, M.D. William N. Davenport has continued as the secretary of the Board, and has acted as its executive officer; and Alfred F. Bridgman has also continued as auditor and accountant.

The office force now comprises a book-keeper, an assistant book-keeper, an assistant in auditing, a paymaster, a supply clerk, three stenographers, one messenger and a janitor.

There has been a considerable increase in the work of the office department. Much time has been required for the investigation of damages, of loss of wages to employes, and claims for the depreciation in value of estates which have not been taken by the Board. The larger amount of construction and the additions to the maintenance service have increased the work attending the accounts and pay rolls.

(2) ENGINEERING DEPARTMENT.

The engineering department, both for the construction of new works and the maintenance of the works of water supply, has been under the direction of Frederic P. Stearns, the chief engineer.

The principal engineers in service have been as follows : —

Chief Engineer, FREDERIC P. STEARNS.

Consulting Engineers, JOSEPH P. DAVIS, ALPHONSE FTELEY, HIRAM F. MILLS.

Engineer of Distribution Department, DEXTER BRACKETT.

Engineer of Sudbury Department, DESMOND FITZGERALD.

Engineer of Dam and Aqueduct Department, THOMAS F. RICHARDSON.

Engineer of Reservoir Department, HIRAM A. MILLER.

Principal Office Assistant, ALFRED D. FLINN.

Superintendent of Pumping Stations, WILL J. SANDO.

There have been employed, on construction and maintenance during the year in the engineering force, in addition to the above, the following : —

Assistant engineers,	27
Assistant superintendents,	2
Draftsmen,	22
Engineering assistants,	141
Inspectors,	15
Sanitary inspectors,	2
Medical inspector,	1
Biologists,	3
Foremen,	14
Clerks,	4
Stenographers,	8
Messengers,	4

making a total of 253 individuals who have been employed in the engineering force at some time during the year.

The maximum number employed in the engineering force at any one time, including those engaged upon the construction and maintenance of the works, was 196.

Besides the engineering force, which included engineers who have been detailed for purposes of inspection of work, other inspectors over pipe-making, pipe-laying, machinery and masonry have been employed, to the maximum number of 15.

The maximum day-labor force was for the week ending June 10, when 343 men were employed. This force, under the general direction of the engineers and under the immediate direction of

foremen, was employed in driving sheet piling at the North Dike of the Wachusett Reservoir, in the construction of a flume and other temporary work at the Wachusett Dam, in digging drainage ditches in swamps, laying pipes in the Metropolitan Water District, and doing other minor work of construction.

There has also been a maintenance force, averaging 117, employed at the pumping stations and in connection with the maintenance and care of reservoirs, aqueducts, pipe lines and other works. The organization of the maintenance force at the end of the year, not including engineers, was as follows:—

Dam and aqueduct department,	9
Sudbury department,	47
Distribution department,	70
Total,	<hr/> 126

The maximum force employed by the various contractors at any one time numbered 2,333 men, for the week ending September 16.

(3) CONVEYANCING DEPARTMENT.

This department has been continued under the supervision of Alfred C. Vinton, conveyancer, assisted by George D. Bigelow, assistant conveyancer. Besides the conveyancer and assistant conveyancer, there have been employed at the Boston office Miss Alline E. Marcy, title examiner, and, for the greater part of the time, two stenographers. The work at the branch office in Worcester has been carried on by Miss Celia M. Tibbetts, under the supervision of Mr. Bigelow, and assisted by one and sometimes two conveyancing clerks and one stenographer.

The regular force in the Worcester branch office has, in addition to the requirements of the Boston office for the recording of papers and furnishing of information from time to time, been engaged in the examination of the titles of lands in West Boylston, for which settlements for indirect damages are required. Considerable assistance has also been rendered in the examination of titles by the examiner at the Boston office. The titles to about 300 parcels of land have thus been examined during the year, and this special work is nearly completed.

Considerable work has also been done in the Worcester office in the preparation of an index of the 8,000 different schedules which have been made in the examination of titles in Worcester County,

so as to render the schedules available for future use; and an index of undischarged attachments in that county has also been completed.

The original examination of the titles outside of Worcester County has been conducted from the Boston office. These titles embraced parcels taken for the Spot Pond improvement, and the extension required by the admission of the town of Arlington into the Metropolitan Water District, and of various lands in which either the fee or easement has been taken for the extension of the pipe lines.

The Boston office has done the work necessary in the completion and perfection of the titles and the preparation of the various papers required from time to time in the 85 settlements which have been made during the year with land owners. These settlements have covered at least 96 separate titles and included some large properties. Considerable additional work has been done in the preparation of papers in settlements which are still pending.

This department has prepared and drafted during the year the instruments of taking of lands under the right of eminent domain. These takings have been 17 in number, involving takings from 74 different owners.

There have also been prepared the necessary instruments for the location of the new highway in Boylston and West Boylston, called the Muddy Brook Road, for the new highway from Clinton to West Boylston, on the northerly side of the reservoir, and for the additional relocation of Boylston Street, on the southerly side of the reservoir in Clinton; and also all the necessary instruments for the discontinuance of several roads and ways in Clinton and Boylston embraced within the limits of the Wachusett Reservoir.

The department has likewise been called upon to furnish to the Attorney-General full reports upon all cases in which petitions for damages have been brought, to make examination of the records for liens and other encumbrances before payments are made upon contracts, and to furnish a great deal of miscellaneous information in regard to real estate required by the Board and by the engineers for their guidance in the various parts of their work.

During the year copies of all the deeds and instruments of takings, from the organization of the Board to December 1, 1899, have been made and bound into books conveniently arranged for use in the future.

(4) POLICE.

In accordance with the requirement that the Board should furnish, without charge, in all towns in which any work is done under the authority of the Act, any police protection which may be necessary in consequence thereof, the Board has paid for the services of officers appointed by the authorities of the various towns in which active work has been carried on.

The number of officers thus appointed by the town of Clinton, was, on July 1, 1899, increased from 6 to 8, and on July 19 to 9, this being the number of officers now paid by the Commonwealth for service in that town. These are all under the control of the chief of police of the town, and are in addition to the six regular officers appointed by the town. In the month of July an arrangement was made with Murphy Brothers of Clinton by which the Board agreed to furnish a patrol wagon for the transportation of all prisoners arrested by special officers paid by the Commonwealth. The Board has also contributed during the year the sum of \$1,500 towards providing additional room at the police station at Clinton.

On June 21 the appointment of one officer for service in the town of Sterling was approved, and this officer was provided with a horse whose maintenance is paid for by the Commonwealth.

The appointment of two officers in the town of Boylston was approved on July 22. One of these was a mounted officer, the maintenance and equipment of whose horse was likewise paid for by the Commonwealth. A police station has been provided in that town and is nearly fitted up for use.

In West Boylston, where but little active work has yet been undertaken, the Board has continued to employ one officer, and he also has charge of the police station, which has been maintained not only for the town of West Boylston, but for other portions of the Wachusett Reservoir district.

Frank H. Baldwin, who is a deputy sheriff for the county of Worcester, has acted as an officer of the Board, not only in the town of West Boylston but also in Boylston and Sterling; and he has in addition a general oversight and care of the property of the Board in these towns, as well as in the town of Clinton.

The officers appointed in each of the towns of Sterling, Boylston and West Boylston have, at the request of the Board, been appointed

as special policemen in the other towns. These towns had not employed regular police officers prior to the operations of the Board.

The building of the Marlborough Brook filter-beds, a part of which work was carried on in the town of Southborough, necessitated the employment of two officers in that town from August 2 to December 16, when the work was finally completed and the officers were discharged. The officers in Southborough were under the direction of the selectmen of that town.

On account also of the carrying on of the work in the city of Marlborough upon the filter-beds, the appointment of two regular officers in the city of Marlborough was authorized on July 3, as well as an additional officer for service on Saturday afternoons and evenings, Sundays and holidays, and on the days when the laborers employed upon the construction of the filter-beds received their pay. The officers in Marlborough were under the direction of the chief of police of that city. The filter-beds having been completed, they were discharged on December 21.

All the officers serving in the above-mentioned towns have been appointed by the selectmen of the towns for which they are respectively on duty, and the officers in the city of Marlborough have been appointed by the mayor of that city.

The Board has authorized the appointment of three additional officers by the Metropolitan Park Commission for service about Spot Pond while the improvements in that region are in progress. Their services are paid for by this Board.

The expenditures for additional police protection thus afforded to the various portions of the district where work was in progress have amounted during the past year to \$11,348.54, and to a total sum, since the year 1895, of \$84,811.46.

No serious cases of disturbance have occurred during the year, and no complaints have been made to the Board that the various districts in which large numbers of workmen have been employed have been greatly disturbed or discommoded by the laborers. The gangs of workmen have generally been kept in good order and discipline, and the Board has been unable to find that the number of arrests in the districts where they have been employed has exceeded the average in other communities in the State where considerable public works are carried on.

(5) OFFICES AND BUILDINGS.

The adjoining buildings, numbered 3 and 2 Mt. Vernon Street, in Boston, have been entirely occupied by the administrative, conveyancing and engineering departments. These buildings, belonging to the Commonwealth, are peculiarly adapted to the needs of the work, on account of the great floor space which is afforded and the unusual opportunities for light and air; and, being so accessible in case of fire, there is very little danger of serious injury by conflagration. It would be impossible to obtain other quarters of the required capacity, with proper facilities for work and of the desirable proximity to the State House, except by the annual expenditure of a large amount of money.

A small office is still retained in Worcester near the Registry of Deeds for the use of the conveyancing department in Worcester County.

The building with fire-proof vaults erected by the Board in Clinton furnishes headquarters for the work on the Wachusett Reservoir, adequate and adapted to the needs of the engineering forces. In Clinton two small branch offices are also maintained near the points where active work is carried on, one on Boylston Street and the other near the North Dike.

An additional office has been established at Sawyer's Mills, in Boylston, and the branch office at West Boylston has been continued throughout the year.

A considerable branch office is maintained for the engineering department in connection with the Sudbury and Cochituate systems at South Framingham.

One of the old buildings acquired by the Commonwealth at Spot Pond has been used as an office for the engineering force employed in the work at the Pond.

At the Glenwood pipe yard, situated near the Glenwood station on the Boston & Maine Railroad, in Medford, which has been made the permanent headquarters of the force in charge of the maintenance department for the northern portion of the District, a considerable building is now in process of erection and approaching completion under plans prepared by Wheelwright & Haven, architects.

The yards for the storage of pipes have also been maintained at

the Brighton station on the Boston & Albany Railroad, and at the Forest Hills station on the New York, New Haven & Hartford Railroad.

Buildings used in connection with the Chestnut Hill pumping station at Chestnut Hill Reservoir have furnished the headquarters for the maintenance and repair force for the southern portion of the District.

Other buildings maintained by the Board for its operations are the pumping stations at Chestnut Hill Reservoir and at Spot Pond, the Clinton Sewerage pumping station, and the various buildings used for operating purposes and dwelling-houses for attendants at the different supply reservoirs belonging to the water works, beside the Mystic pumping station, which is now out of service.

II. WORK OF CONSTRUCTION.

(1) WACHUSETT DAM, RESERVOIR AND WATERSHED.

(a) *Wachusett Dam.*

The work accomplished toward the building of the Wachusett Dam has continued to be largely of a preliminary nature. Much study and investigation has been given as to the definite plans and specifications for the structure itself. Additional borings have been made near the site of the dam. The flume, built for the purpose of carrying away the excess of the water of the river above that which is diverted, has been extended so as to cover the entire site of the dam. Considerable rock excavation in the bed and at the sides of the river has been made in order to obtain a suitable foundation for the dam, but this excavation has not yet been carried to so great a depth as it seems desirable to reach. Some of the quarries upon land of the Commonwealth near the dam have been opened, and it is expected that they may be availed of for furnishing a portion at least of the stone which will be required in construction.

(b) *Wachusett Reservoir.*

Substantial progress has been made in the stripping of the soil from the bottom of the reservoir and in the building of the northern of the dikes, which, extending to the higher grounds on either side of the river, are to flank the masonry dam as barriers against the water

in places where the surface of the land is lower than the high-water level of the proposed reservoir. Contracts have been made for the removal of the soil from more than one-half of the lands which are to be submerged, and satisfactory progress has been made during the past season in the actual removal of soil. The larger part of the soil to be removed is taken to form a part of and to strengthen the dikes.

In the lands along the line of the North Dike two cut-off trenches, primary and secondary, have been dug, the larger having a depth varying from 30 to 60 feet, and a width of 30 feet at the bottom. By this work the gravel and coarser sand are removed down to a depth where the nearly impervious sand is usually reached, and the trench is filled again with fine soil brought from the bottom of the reservoir, which is made compact and water-tight by watering and rolling. In places, however, where the material found at the bottom of the trench is somewhat pervious, triple-lapped piling or sheeting of spruce plank has been driven to a depth sometimes exceeding 60 feet below the bottom of the trench and for a total length of 3,798 linear feet. These precautions are taken to prevent the loss of water by percolation through or under the dike.

(c) Construction of Roads.

A section of the new road, 3 miles in length, extending from near the Lancaster Mills in Clinton into Boylston, and following principally the old line of Boylston Street, which had nearly reached completion in the year 1898, has been finally completed during the past year, and was found by the County Commissioners to be constructed in accordance with the requirements fixed upon in the agreement for its construction made between the Commissioners and the Board. The road was surfaced with trap rock, and has in no place a grade exceeding 6 per cent. The cost of building this road, exclusive of engineering, preliminary and additional work, was \$69,406.69.

The Board laid out the continuation of the road from Boylston to West Boylston, following substantially the margin of the reservoir, in accordance with the original scheme of the State Board of Health. It was not able, however, to reach an agreement with the County Commissioners, whose assent was necessary before building the road, the Commissioners believing that the road should be extended

across the southerly arm of the reservoir, requiring the construction of a long and high embankment. The matter was, therefore, referred, in accordance with the Act, to the Highway Commission for a final adjudication. The decree of the Highway Commission was made on May 6, 1899, requiring the road to be built substantially as laid out by the Water Board, extending it, however, southwesterly also to the Shrewsbury Road, a distance of 5,809 feet. The work of building this road was begun soon after the decree of the Highway Commission was made, and considerable progress has been made towards its completion.

A beginning was made last year in the construction of the road which is to extend along or near the North Dike upon the northerly side of the reservoir, from Clinton to West Boylston and Sterling, and its construction has been continued through the year. The portion of this highway extending from Clinton to Lancaster Street in West Boylston, a distance of 13,607 feet, has been made nearly ready for public use. Lancaster Street, which is to form a continuation of the road, has been improved by the reduction of the grades and the widening of the travelled way for a distance of 8,508 feet, to Beaman Street in West Boylston.

For the continuation of this road in the village of West Boylston to the village of Oakdale various surveys have been made, but the route has not been absolutely determined; neither has a definite determination been reached as to the location of the roads in Oakdale.

(d) *Relocation of the Central Massachusetts Railroad.*

Further investigations and surveys have been made during the year for the purpose of determining the relocation of the Central Massachusetts Railroad. Not only have the routes considered by the engineers of the Board been surveyed, but additional surveys have been made at the request of the people living in the different towns, who are interested in various routes suggested. As many as 13 different routes have been taken into consideration, and actual surveys for them made.

The Metropolitan Water Act provides that the Board may make such relocation "as, and in such manner as, shall be mutually agreed upon by said water board and the board of directors of the railroad company; and if they cannot agree thereon, then as, and

in such manner as, shall be determined on the application of either party, in writing, by the board of railroad commissioners."

Several conferences have been had with the officials of the railroad company, and in October last the results arrived at were considered by the Board and the officers of the company, and it is believed that substantial progress has been made toward a mutual agreement. It is confidently anticipated that a definite arrangement will be reached at an early date.

(e) *Clinton Catholic Cemetery.*

The Board had, on July 1, 1898, in accordance with the expressed desire of the people most interested in Clinton, entered into an arrangement with the Right Reverend Thomas D. Beaven, the Roman Catholic Bishop of Springfield, the owner in fee of the St. John's Catholic Cemetery, and the St. John's Catholic Cemetery Association, by which a tract of land was to be acquired in the southerly part of Lancaster, to which the bodies in the old cemetery should be removed, the entire work of removal to be carried on by the Cemetery Association. It was provided that the sum of \$92,500 should be paid in instalments from time to time as the lands should be acquired, as the new grounds should be prepared for burial purposes, and as the removal of bodies should be made.

Under this agreement the Board had paid for and obtained title to suitable lands for the new cemetery, which were satisfactory to all the parties concerned and which were to be subsequently conveyed to the Association, and the Association had made considerable progress in the preparation of the grounds. The work of the Association was continued during the year 1899, until May 13, when some difficulties arose in the Association and the entire work was necessarily suspended. The Board, however, with the assent of the Bishop, continued the work of preparing the grounds, under the charge of Harold Parker, who was the engineer of the Cemetery Association.

At the request of the parties most interested in the cemetery, a supplementary agreement was made by the Board and the Bishop, by which it was provided that the removal of the bodies from the old cemetery should be made, not by the Cemetery Association, but by a committee composed of officers of the Association and representatives of the lot owners.

Under the supplementary agreement, the actual removal of bodies began on December 19, and has since been carried on very satisfactorily, a total of 157 bodies having been removed from the old cemetery and reburied in the new grounds up to December 31, 1899.

(f) *Sanitary Inspection.*

Especial attention has been given during the past year to the sanitary condition of houses and camps in which laborers have lived, and in general to the grounds upon which work is carried on within the Wachusett basin. Dr. John J. Goodwin of Clinton has been regularly employed as a medical inspector to visit the various camps and houses and to assist the sanitary officers of the Board. The contractors have been required to keep their camps and hired houses in clean condition, and the discharge of the drainage from the camps, as well as of the sink drainage from other buildings, upon the lands to be submerged, has, so far as possible, been prevented from being made.

(g) *Financial Summary.*

The following is a summary showing the purposes of expenditures on account of the Wachusett Dam, Reservoir and Watershed: —

	For the Year ending December 31, 1899.	From Beginning of Work, and ending December 31, 1899.
Contracts for construction,	\$289,161 64	\$394,850 79
Real estate: —		
Mill property and water rights,	199,700 00	1,310,700 00
Other property for reservoir and margins,	126,776 85	907,764 07
Outlying property,	5,930 66	19,677 66
Damages to real estate not taken, to business, and on account of loss of wages,	17,059 00	44,108 68
Engineering,	73,966 34	238,854 85
Preliminary and additional work, taxes and other expenses,	145,083 33	410,362 41
	\$857,677 82	\$3,326,318 46



CLINTON SEWERAGE — PUMPING STATION.

THE NEW YORK
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ASTOR LENOX AND
TILDEN FOUNDATION.

(2) WACHUSETT AQUEDUCT.

The Wachusett Aqueduct was substantially completed in the year 1898. The aqueduct has required but little attention during the past year.

Owing to the fact that several of the wells in West Berlin had been drained by the construction of the tunnel, attempts have been made to furnish a satisfactory water supply to take the place of the wells which had to be abandoned. The work, however, which had hitherto been done proved hardly sufficient, especially in a dry season, and additional sources of supply have been gained by the digging of an additional well and the extension of the pipe line, which seem to remedy all of the troubles.

Settlements have been effected in 42 out of the total of 44 claims for land damages made on account of the construction of the tunnel and covered aqueduct, leaving only 2 claims to be settled. Ten claims for land damages on the open channel have been settled, leaving 12 cases still pending.

Considerable amounts have been paid during the past year in final settlements of contracts for work upon the aqueduct, which had been substantially completed in the year 1898.

The following table shows the purposes of the expenditures on account of the Wachusett Aqueduct:—

	For the Year ending December 31, 1899.	From Beginning of Work, and ending December 31, 1899.
Contracts for construction,	\$30,907 55	\$1,446,403 89
Real estate settlements,	12,130 00	60,441 40
Engineering,	2,813 94	161,255 11
Preliminary and additional work and other ex- penses,	4,248 97	95,405 26
	\$50,100 46	\$1,763,505 16

(3) CLINTON SEWERAGE.

The work of constructing a plant for the disposal of the sewage of the town of Clinton was completed in September, and all of the

sewage of the town has been disposed of by the new system since September 15, 1899. An intercepting sewer, about 2,190 feet in length, was built to convey the sewage coming from the various town sewers to a point near the bank of the river below the town, where a receiving reservoir was constructed, capable of holding 669,200 gallons. Adjoining the reservoir was built a pumping station, from which the sewage is forced through an iron pipe, across the river, into a gravelly field in the town of Lancaster. Most of the soil and loam overlying the sand have been removed from this field, and filter-beds, to the number of 25 and having an area of $23\frac{1}{2}$ acres, have been constructed. From these filter-beds the water flows by percolation through the gravel, and afterwards finds its way, free from deleterious matter, back into the river.

The cost of the sewerage plant has been \$107,967.49.

(4) NASHUA MEADOWS.

A large number of claims for compensation have been made by the owners of the lower lands and meadows situated on the river below the more inhabited portions of the town of Clinton, in Clinton, Lancaster and Bolton, for injuries which it is alleged have resulted from the decreased flow of water, and especially by reason of the loss of the fertilizing advantages which are claimed to have come from the greater overflow of the lands in the periods of spring freshets. The owners of the lands have been given hearings and their various claims have been presented, but it has been found to be a most difficult matter to anticipate what will be the result to these lands from the decreased freshets which are likely to come in the future.

The Board has caused not only much investigation to be made by its own engineers, but has endeavored to obtain the best advice possible, both from experts and from practical agriculturists living in the vicinity.

The want of any considerable freshet during the past year has interfered with obtaining all the facts desired, and it has not been possible yet for the gentlemen employed to make a satisfactory final report. It has been deemed wiser, before reaching a determination as to these claims, to get the experience which may be afforded by the coming season.



MARLBOROUGH BROOK FILTER-BEDS.

100

100

(5) SUDBURY DAM AND RESERVOIR.

Considerable work has been done during the year in clearing up the débris below the Sudbury Dam, grading and otherwise improving the grounds, and removing the office building to a more satisfactory site at a greater distance from the dam. This building has been put into good repair, and changes have been made by which it can be used as the residence of the attendants required for the care of the dam and the grounds in the vicinity.

Five claims for damages on account of the taking of lands included in the reservoir have been settled during the year. Only two small claims remain for final settlement, and in these the amounts to be paid have been agreed upon, and there only remains the execution of the necessary deeds.

A considerable amount was paid early in the year on account of contracts which had been finished late in the preceding year.

The following is a summary of the purposes of the expenditures made on account of the Sudbury Dam and Reservoir:—

	For the Year ending December 31, 1899.	From Beginning of Work, and ending December 31, 1899.
Contracts for construction,	\$40,991 69	\$1,949,448 77
Land settlements,	27,495 15	619,343 43
Engineering,	3,047 38	172,376 37
Preliminary and additional work and other expenses,	7,599 94	176,077 37
	\$79,134 16	\$2,917,245 94

(6) IMPROVEMENT OF THE SUDBURY WATERSHED.

(a) *Marlborough Brook Filter-beds.*

During the year the construction of filter-beds has been undertaken and accomplished, by which the water flowing down the Marlborough Brook is filtered before it is allowed to enter the Sudbury Reservoir. Inasmuch as the brook flows directly through the city of Marlborough, the water is much contaminated by street washings and other foul matter.

Under the new construction the water from the brook is first received in a settling reservoir, from which it passes through an open channel, about half a mile in length, skirting the various beds at a higher level, and from this channel, by a system of gates, the water is drawn into the beds for filtration. There are 17 so called "artificial" filter-beds, having a total area of 5.36 acres. These are built in terraces upon a nearly impervious soil, divided into beds by embankments, and containing, as filtering material, a depth of 24 inches of sand supported upon several layers of gravel of graded sizes, and underdrained by vitrified pipes. There are in addition 8 so called "natural" filter-beds, having an area of 8.63 acres. These beds were built upon the site of gravelly knolls, the upper portions of which were removed to furnish the gravel and sand for the filling of the artificial beds. After this upper material was removed, the natural gravelly beds were formed by surrounding the excavated areas with embankments. These natural beds are not underdrained, but are surrounded by lines of vitrified pipes laid with filter joints. It is hoped that the beds will prove sufficient to filter the contents of the brook at its highest flow.

The expenditures on account of the Marlborough Brook filter-beds, including work done by the city of Boston, are as follows : —

	For the Year ending December 31, 1899.	From Beginning of Work, and ending December 31, 1899.
Contracts for construction,	\$35,522 17	\$49,806 16
Land settlements,	—	37,626 32
Engineering,	8,413 44	14,831 70
Preliminary and additional work, and other expenses,	1,636 22	3,116 62
	\$45,571 83	\$105,380 80

(b) *Swamp Drainage.*

The work of swamp drainage, which had been begun in the previous year, has been vigorously prosecuted during the year 1899, in general by constructing ditches near the edges of the swamps in order to intercept the water from the uplands and convey it directly

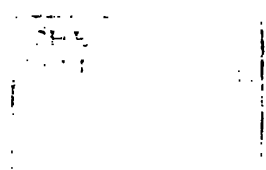


SWAMP DRAINAGE — SWAMP BEFORE DRAINAGE.

13



SWAMP DRAINAGE - SWAMP AFTER BUILDING OF DRAINAGE DITCHES.



to the reservoirs, without its coming in contact with the vegetable matter in the swamps. The swamps, being isolated by the construction of the ditches, become moderately dry, as they receive little water except from the fall of rain directly upon them.

This work has been carried on both by the dam and aqueduct department and by the Sudbury department.

The largest of the swamps, which was tributary to the open channel of the Wachusett Aqueduct, has an area of 460 acres, with a tributary watershed of 2.9 square miles, and in this ditches have been constructed having an aggregate length of 45,250 feet.

The swamps around Brigham's Pond in the town of Southborough have been improved, and the pond itself, which had an area of 14 acres, has been drained. In connection with this improvement, ditches have been dug of a length of 11,811 feet.

Three other smaller swamps, also tributary to the open channel, have been improved by ditching.

The total length of ditches constructed in the swamps having an outlet into the open channel was, in the year 1899, 65,075 feet, which, added to the 15,231 feet constructed in 1898, makes a total length of ditches of 80,306 feet, equal to 15.2 miles. The total area of these swamps which have been thus improved is 667 acres.

Similar work has been done in the draining of three swamps which are directly tributary to the Sudbury Reservoir and Framingham Reservoir No. 3.

The largest of these three swamps is Angelico Swamp, which is situated mostly in the town of Southborough. The other swamps drained by the Sudbury department have been Brewer Swamp and Deerfoot Swamp, both situated in the town of Southborough. The work in Deerfoot Swamp, however, has not yet been completed.

The total number of feet of ditching accomplished by the Sudbury department has been 20,302.

Work has also been begun in the improvement of a swamp in Boylston, which is tributary to the Wachusett Reservoir.

The work upon the swamps has been carried on by day-labor forces, as it was not of a nature which could be reasonably specified in advance. The forces employed have averaged during the time of active operations about 119 men.

It seemed to be the better policy in Crane Swamp, as a rule, to purchase or take the land; but in most of the other cases per-

mission has been obtained to do the ditching, generally without payment to the owner of the land. The drainage has usually had a beneficial effect upon the smaller swamps ; and at the same time there has been a decided improvement in the character of the water by reason of the work which has been done.

Following is a summary of the expenditures on account of swamp drainage, and other work for the improvement of the watershed : —

	For the Year ending December 31, 1899.	From Beginning of Work, and ending December 31, 1899.
Day work in construction,	\$36,462 79	\$46,040 43
Land settlements,	7,807 00	9,671 50
Engineering,	9,434 31	15,929 00
Other expenses,	516 15	725 75
	\$54,220 25	\$72,366 68

(7) CHESTNUT HILL PUMPING STATIONS.

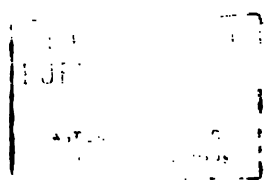
The foundations for the new low-service pumping station had been partially completed at the end of the year 1898. During the year 1899 the work of constructing the pumping station has been actively carried on, and the exterior stone and brick work, as well as the roof, have been completed. Considerable delay has been suffered in obtaining the cast-iron frames for the large windows of the main structure. The entire building will, however, it is anticipated, be completed in the early spring.

The three pumping engines contracted for, each having a capacity for pumping 35,000,000 gallons per day, as well as the necessary boilers, have been partially completed, and a portion of the castings have been received and put in place. It is expected that two of the three engines will be in readiness for use in the coming summer.

The operation of these engines will be of great service in relieving the other pumping station of a portion of the strain which has been put upon it, and will also enable the Board to furnish an additional pressure to many portions of the city of Boston where such additional pressure is much desired.



CHESTNUT HILL RESERVOIR IN BOSTON, WITH HIGH AND LOW SERVICE PUMPING STATIONS.



The completion of the additional pumping station at Chestnut Hill Reservoir will be an important step in the work of ensuring to the district a better distribution of the additional supply of water.

The new Allis engine which has been placed in the addition to the old station, and which was first started in December, 1898, has been completely finished, and, although it has not received the final test, has been put into regular service, and, except for short interruptions, has been constantly in operation since April 13.

A new gate-house is in process of erection on the shore of the Chestnut Hill Reservoir, in order to provide for supplying water to the new pumping station and also for increasing the supply for the old station.

The large pipes for connecting with the new pumping station have nearly all been laid, but the final connections remain to be made.

The addition of the new Allis engine and of the other facilities which have been introduced during the year have brought about a favorable result in the cost of operation. The quantity of water pumped during the year has increased by 30 per cent. over that of the preceding year, while the cost of pumping has increased only 8 per cent. The large saving which is due to concentrating the operations of pumping to fewer and larger stations, and to more efficient machinery, has been forcibly exhibited by the results obtained at the Chestnut Hill station.

Both the Chestnut Hill and Mystic stations were operated during the years 1896 and 1897 by the city of Boston. Upon the taking of the works of the city by the Metropolitan Water Board, the Mystic station was abandoned, and the work of the two stations was performed by the Chestnut Hill station alone. The cost of pumping each million gallons of water in the year 1896 was \$6.72, and in the year 1897 \$5.89. This cost per million gallons was decreased in the year 1898 to \$3.21, and in the year 1899 to \$2.66. The saving made by pumping a great quantity of water at a single station is also shown by comparing the cost of pumping the large quantities of water at the Chestnut Hill station with the cost of pumping comparatively very small quantities of water in the several stations belonging to the various cities and towns which have been operated during the year at the expense of the Board, but which have been, as the Board has reason to believe, economically managed by the

local authorities. In these small stations the cost per million gallons has varied from \$8.68 to \$24.12, as against \$2.66 per million gallons at the Chestnut Hill station.

(8) SPOT POND.

The work of removing mud and other organic matter which are deposited in the bed of Spot Pond, and of otherwise improving the pond for the purpose of a storage and distributing reservoir, was begun in April, 1899. It was deemed necessary that at the same time the pond should be raised 9 feet above its previous high-water level, in order to afford a larger supply of water, near at hand, in case an emergency should arise.

The material in the bed of the pond is removed so as to give a minimum depth, below the future high-water level, of 15 feet. Where this excavation does not remove all of the mud, the excavation is continued so as to include the mud down to a depth in all of 23 feet. The mud in other portions of the pond, laid bare by the drawing down of the water, is covered with a layer of sand 1 foot in thickness, but the upper portion of the mud is first excavated if the depth over it is less than 16 feet. In the smaller portion of the pond, where the depth of the water will be more than 23 feet, the bottom has not been disturbed, as it is not feasible to remove it. It is not believed, however, that any organic matter remaining will cause serious injury.

The pond will have a level 29 feet above that of Chestnut Hill Reservoir. This higher level will facilitate the supply by gravity of many portions of the district supplied by the low service, and at the same time the capacity of the pond will be increased from 758,300,000 gallons to about 1,800,000,000 gallons. The earth removed from the bed of the pond is deposited upon the bordering shores and the adjoining low lands.

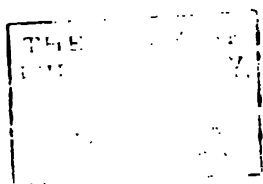
The raising of the pond has necessitated the raising and relocation of about $1\frac{1}{2}$ miles of streets or parkways, and the building of several low dams or dikes in order to prevent the pond from overflowing.

The building of a drainage system has also been required in order to divert into the outlet brook the water of some of the smaller streams which had drained populated districts or had run through low and swampy territory into the upper part of the pond.

The raising of the pond has carried the water level above some



SPOT POND — COVERING WITH SAND THE DEEPER MUD AT BOTTOM OF POND.



considerable portions of the lower adjoining lands, and, in consequence and as a part of the scheme of improvement adopted, two smaller ponds, one upon the west and one upon the south, will be formed, which, however, will not be made directly a part of the water supply.

The entire treatment of the margins of the pond has been made and the roads have been relocated under the advice of Olmsted Brothers, landscape architects, with the purpose that the natural beauty of the pond shall not be marred, but that its attractiveness in the midst of the Metropolitan Park System shall, if possible, be enhanced.

The larger part of the work of improvement has been carried on in 5 sections by 3 different contractors. A proper treatment of a portion of the shores could not, however, be determined in advance of actual operations, and so a considerable work in addition has been done under the immediate supervision of the engineers of the Board.

So much has been accomplished during the past year, it is expected that the entire work of improvement will be completed by the middle or end of the summer of 1900.

The following table gives a summary of expenditures on account of work at Spot Pond:—

	For the Year ending December 31, 1899.	From Beginning of Work, and ending December 31, 1899.
Contracts for gate-houses, inlets, earthwork and drainage system, also core wall,	\$186,441 94	\$205,246 96
Land settlements,	53,600 00	53,600 00
Engineering,	39,559 12	54,465 25
Preliminary and additional work and other expenses, including day-labor,	65,334 86	71,744 10
Totals,	\$344,935 92	\$385,056 31

(9) NORTHERN HIGH-SERVICE PUMPING STATION AND GATE-HOUSE.

A contract for building the northern high-service pumping station and the superstructure of a small gate-chamber on the easterly shore of Spot Pond, for which plans had been prepared, was made

with McNeil Brothers on January 17, 1899. Work was begun in March, and the exterior of the pumping station has now been nearly finished.

The Leavitt pumping engine, having a capacity of 10,000,000 gallons per day, has already been removed from the old Mystic pumping station and set up in the new station, and considerable progress has been made in the building of the new 20,000,000-gallon engine, for which a contract had been made.

The superstructure of the gate-house at the easterly side of the pond has been nearly completed.

(10) FELS RESERVOIR.

The reservoir in Middlesex Fells for the northern high service, which had been partially constructed in the year 1898, has been finished and is now filled with water.

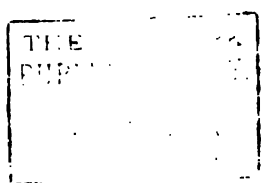
This reservoir is situated in the higher part of the Fells reservation, about 2,500 feet southeasterly from Spot Pond. It is located in a natural basin, at so high a point in the Fells that the surface of water in the reservoir will be 137 feet above the level of Chestnut Hill Reservoir and 108 feet above that of Spot Pond. The larger part of this natural basin is so bedded with and surrounded by rocks that the work of construction consisted largely of the removal of the soil and mud from the surface of the rocks. Five short dams, having an aggregate length of less than 1,000 feet, were required to supplement the rocky barriers. These dams are constructed with core walls of concrete masonry, and covered with earth embankments faced with gravel, so as to give a natural appearance. By utilizing a natural ridge of rock and constructing two short walls of concrete masonry, the reservoir will be divided, when drawn down 6 feet, into two distinct basins.

The entire bed of the reservoir is made to be of a substantially uniform depth of 21 feet, and is floored with concrete. A 36-inch pipe main is laid through the reservoir to the gate-house built at the outlet of the reservoir, so that the water can be delivered from the pumps into either basin or to the District; water can also be drawn from either basin independently, so that each basin may be emptied without interfering with the supply, and may be kept in absolutely clean condition.

The superstructure of the gate-house is built of seam-faced granite, with trimmings of Deer Isle granite, and the roof is cov-



FELLS RESERVOIR — COMPLETED.



ered with red tiles. This superstructure is built from plans by Shepley, Rutan & Coolidge.

The grading of the ground about the reservoir has been done in accordance with plans made by Olmsted Brothers, in such manner as to harmonize with the surroundings. The reservoir, it is believed, has proved an added attraction, rather than an injury, to the surrounding park.

The reservoir has an area of 8.52 acres and a capacity of 41,400,000 gallons. Its cost, as of January 1, 1900, has been \$134,776.32.

(11) MAIN DISTRIBUTING PIPE LINES.

The principal work in pipe laying done during the past year has been the completion of the line for the supply of Nahant and Swampscott, the laying of pipes for the supplying of Arlington, and the laying of pipes for connections at the low-service pumping station at Chestnut Hill Reservoir and the northern high-service pumping station at Spot Pond.

The rebuilding by the Fitchburg Railroad Company of the bridge crossing the railroad in Massachusetts Avenue in Cambridge required a considerable change in the pipes which were laid in connection with the bridge.

The following is a summary of the purposes of the expenditures for pipe lines and connections in the distribution system : —

	For the Year ending December 31, 1899.	From Beginning of Work, and ending December 31, 1899.
Contracts for pipes, valves, pipe-laying, etc, .	\$77,711 38	
Less value of pipes, valves, etc., purchased and sent to store yards in previous years, but trans- ferred to works, and included in cost of same for the current year,	25,598 86	
	\$52,112 52	\$1,966,026 23
Land settlements,	3,487 50	9,999 00
Engineering,	12,538 95	164,787 23
Preliminary and additional work and other ex- penses,	27,152 21	151,146 80
Totals,	\$95,291 18	\$2,291,959 26

(12) PURCHASES AND TAKINGS OF LAND.

The Board, in accordance with the policy established at the outset, has endeavored to acquire, so far as possible, the various lands and estates required in the construction of the works and for its other operations, through voluntary settlements with the various owners, believing this policy to be for the interest and accommodation of the owners and occupants. It was at the same time impossible for the Board to complete the proper surveys and definitely determine the amounts required, so as to make early takings throughout the region to be embraced in the Wachusett Reservoir.

Takings of the land to be submerged in the reservoir have been made from time to time during the year as the work has advanced and the final plans and determination as to margins have been reached.

By far the larger part of the land embraced within the margins of the Wachusett Reservoir, as proposed in the scheme adopted by the Act, has been so acquired, and deeds of these lands have been taken to the Commonwealth. In most cases of purchases, a formal taking of all rights in the lands has been made under the authority of the Act, after their acquisition by deed.

The beginning of the work of stripping the soil within the limits of the Wachusett Reservoir during the past year has, however, necessitated the taking of lands for which negotiations have not been completed. In all cases, however, in which settlements have been effected after the taking, releases have been obtained from the owners on payment of damages.

The number of acres of land in the different localities, which, with the buildings thereon and any water rights and machinery connected therewith, have been either conveyed or released to the Commonwealth for the various operations of the Board during the past year, have been 1,000.09, for which the owners have been paid the sum of \$332,407.51. These settlements have been made with 39 different parties. The total number of acres which have been so conveyed or released since the beginning of the work has been 5,779.99, for which the sum of \$2,238,141.73 has been paid. This total sum has been paid to 252 parties. The sums paid have included compensation for water damages, mills and other buildings connected with the lands acquired. These settlements embrace 2 cases in which the amount paid has been determined by suit in court, and the amount thus recovered has been \$13,036.93.

The following table shows the purposes for which the lands have been acquired and the location of the lands for which settlements have been made, the number of acres settled for and the amounts paid, both for the year 1899 and for the entire period since the beginning of the work : —

Summary of Land Settlements to December 31, 1899.

LOCATION.	FOR THE YEAR 1899.			FROM BEGINNING OF WORK.		
	Area in Acres.	No. of Settlements.	Payments.	Area in Acres.	No. of Settlements.	Payments.
<i>Wachusett Reservoir.</i>						
Clinton,	205.59	39	\$332,407 51	1,095.07	252	\$2,238,141 73
Boylston,	447.29			2,737.82		
West Boylston,	78.43			1,178.12		
Sterling,	46.32			532.01		
Lancaster,	55.50			69.97		
Holden,	167.00			167.00		
Total,	1,000.13	39	\$332,407 51	5,779.99	252	\$2,238,141 73
<i>Wachusett Aqueduct.</i>						
Berlin,	-	10	\$12,130 00	42.44	53	\$60,441 40
Northborough,	11.41			82.56		
Southborough,	37.93			47.16		
Marlborough,	9.06			43.72		
Clinton,	1.64			13.61		
Total,	60.04	10	\$12,130 00	229.39	53	\$60,441 40
<i>Sudbury Reservoir.*</i>						
Southborough,	24.88	5	\$27,495 15	1,991.09	147	\$656,969 75
Marlborough, . . . . .	.06			746.12		
Total,	24.94	5	\$27,495 15	2,737.21	147	\$656,969 75
<i>Improvement Sudbury Watershed.</i>						
Northborough,	66.38	16	\$7,807 00	103.81	24	\$9,671 50
Southborough,	2.66			2.66		
Westborough,	152.53			187.24		
Total,	221.57	16	\$7,807 00	293.71	24	\$9,671 50
<i>Clinton Sewerage System.</i>						
Clinton,	1.20	4	\$4,020 00	1.20	8	\$8,200 00
Lancaster, . . . . .	.42			43.63		
Total,	1.62	4	\$4,020 00	44.83	8	\$8,200 00
<i>Distribution System.</i>						
Boston, . . . . .	.35	11	\$65,367 50	.70	20	\$95,268 32
Brookline,	-			.05		
Arlington,	1.80			1.80		
Malden, . . . . .	.16			.16		
Medford, . . . . .	.12			2.39		
Newton, . . . . .	.06			.06		
Quincy,	-			5.23		
Stoneham,	12.82			16.81		
Total,	15.31	11	\$65,367 50	27.20	20	\$95,268 32
Aggregate,	1,323.61	85	\$449,227 16	9,112.33	504	\$3,068,692 70

* Including settlements made by city of Boston.

During the year 1899, 17 takings of real estate have been made, embracing an area of 1,286.04 acres. The larger part of the takings have been of lands situated in Worcester, Middlesex and Suffolk counties. The greater portion of the land taken was for the Wachusett Reservoir, but a considerable acreage was taken for the improvement of the Sudbury watershed. A tract of land was also taken in Arlington for the erection of the pumping station. Easements in smaller tracts of land have been taken for pipe line purposes. Of the total area of 1,286.04 acres, the fee has been taken in 1,274.67 acres and easements in 11.37 acres.

The purposes and location of the various takings made during the past year, the nature of the takings and the number in which settlements have been made are shown by the following table:—

TOWN.	Fee.	Easement.	Settled.
<i>Wachusett Reservoir.</i>			
Boylston,	Acres. 510.410	Acres. —	Acres. 354.130
Clinton,	1.336	.356	—
Lancaster,	8.050	—	8.050
Sterling,	271.010	—	247.680
West Boylston,	76.480	.330	61.860
	867.286	.686	671.720
<i>Wachusett Aqueduct.</i>			
Berlin, . . . . .	.200	.300	.500
<i>Improvement Sudbury Watershed.</i>			
Northborough,	176.530	7.862	103.760
Marlborough, . . . . .	.800	—	—
Southborough,	—	2.166	—
Westborough,	178.620	—	164.310
	355.950	10.028	268.070
<i>Distribution.</i>			
Arlington,	1.802	.094	1.896
Brighton, . . . . .	.335	.013	.348
Malden,	—	.071	.071
Medford,	36.000	.177	.177
Stoneham,	13.100	—	—
	51.237	.355	2.492
Aggregate,	1,274.673	11.369	942.782

Land not previously purchased has been taken from 74 different owners, with 38 of whom settlements have been effected.

Of the 4,625.70 acres of land taken by the Board for the Metropolitan Works since the beginning of operations, aside from the takings made of the water works of the cities of Boston, Malden,

Medford and Melrose, settlements have been effected with the owners of all but 634.26 acres.

A complete list of the takings of the Board made prior to the year 1899, numbered 1 to 38 inclusive, will be found in the Fourth Annual Report of the Board. The following is a list of all takings made in the year 1899:—

List of Takings from January 1, 1899, to January 1, 1900.

No.	LOCATION AND DESCRIPTION.	Former Owners.	Recorded.	Purpose of Taking.
39	Clinton (southwesterly from South Main Street to land late of Edward and Alice G. Garrity). Area, 1.336 acres in fee; easements in 0.356 acre.	Geo. A. Dorrisson, heirs of Owen Kittredge, Edward and Alice G. Garrity, Catherine McGuinness and Nellie E. Burke.	1899. Jan. 17.	Highway, Wachusett Reservoir.
40	Malden (northerly side Medford Street and westerly side Malden River). Area, easements in 0.071 acre.	Elisha S. Converse.	Jan. 19.	Pipe line.
41	Lancaster (southerly part, and northwesterly of road to Clinton called Parker Road). Area, 8.05 acres in fee.	Martin Murphy and John W. McNamara.	Feb. 20.	St. John's Catholic Cemetery Association, Wachusett Reservoir.
42	Marlborough (adjoining Northborough and near New York, New Haven & Hartford Railroad). Area, 0.80 acre in fee.	Chloe Ann Ballou and heirs of Henry Barnes.	Mar. 20.	Crane Swamp, improvement of Sudbury watershed.
43	Northborough and Westborough (from Middlesex County line and New York, New Haven & Hartford Railroad in Northborough to Haskell Street in Westborough). Area, 325.45 acres in fee.	Chloe A. Ballou, heirs of Henry Barnes, Charles E. Nichols <i>et al.</i>	Mar. 20.	Crane Swamp, improvement of Sudbury watershed.
44	Medford (20-foot strip extending southeasterly from Arlington Street in proposed extension of Jerome Street). Area, easements in 0.177 acre.	Owners unnamed, land probably now or late of G. Edward Smith and Isabel Craig.	April 4.	Pipe line.
45	West Boylston and Sterling (between the road from Sawyer's Mills to Sterling and Lancaster streets. Also right to alter location of Lancaster Street). Area, 5.18 acres in fee; easements in 0.33 acre.	Heirs of Thomas H. O'Conner, heirs of Herbert F. Newton, Olive A. Hager and Louis Bond.	April 4.	Highway, Wachusett Reservoir.
46	Berlin (westerly part). Area, 0.20 acre in fee; easements in 0.30 acre.	Eliza A. Barnes.	May 2.	Pipe line.
47	Arlington (near Brattle Street and way into said street). Area, 1.802 acres in fee; easements in 0.094 acre.	Ralph L. Perry.	May 4.	Pumping station.
48	Boston (near Reservoir Lane and Boston & Albany Railroad in Brighton). Area, 0.336 acre in fee; easements in 0.018 acre.	Owners unnamed.	June 12.	Addition to Pumping Station lot at Chestnut Hill Reservoir.
49	Northborough (south side of New York, New Haven & Hartford Railroad). Area, 29.70 acres in fee; easements in 7.862 acres.	Charles E. Nichols <i>et al.</i>	July 6.	Little Crane Swamp, improvement of Sudbury watershed,

List of Takings from January 1, 1899, to January 1, 1900 — Concluded.

No.	LOCATION AND DESCRIPTION.	Former Owners.	Recorded.	Purpose of Taking.
50	Boylston and West Boylston (on Temple Street or the Sand Hill Road, Hartwell Street and county road to Holden). Area, 16.55 acres, in fee.	Levi L. Flagg, Geo. W. Ames <i>et al.</i>	July 27.	Wachusett Reservoir.
51	Medford and Stoneham (on Spot Pond, Woodland Road and Forest Street). Area, 49.10 acres in fee.	City of Medford.	Aug. 5.	Spot Pond Improvement.
52	Boylston and West Boylston (both sides of road to Worcester from Boylston Centre). Area, 30.97 acres in fee.	William R. Albertson and Levi L. Flagg.	Aug. 17.	Wachusett Reservoir.
53	Boylston (easterly from land late of Geo. A. Flagg to the Worcester road and from said road to the South Road). Area, 6.22 acres in fee.	Henrietta M. and Calvin H. Andrews, George W. Shattuck <i>et al.</i>	Aug. 31.	Highway, Wachusett Reservoir.
54	Sterling, Boylston and West Boylston (northwesterly of Boston & Maine Railroad between Sterling and Sawyer's Mills Road and Lancaster Street). Area, 798.980 acres in fee.	Nathaniel L. and Everett Kendall <i>et al.</i>	Oct. 11.	Wachusett Reservoir.
55	Southborough (northerly part near Sears Street and New York, New Haven & Hartford Railroad). Area, easements in 2.166 acres.	J. Montgomery Sears.	Oct. 23.	Improvement of Sudbury watershed.

(13) CLAIMS FOR DAMAGES TO BUSINESS.

Claims for injury to business by the carrying out of the Metropolitan Water Act, through loss of custom or otherwise, may, under the Act and by subsequent statutes, be brought by any individual or firm owning an established business on April 1, 1895, on land in the towns of West Boylston, Boylston, and in that portion of the town of Sterling situated near the proposed work. Considerable progress has been made in the past year in the settlement of this class of claims.

During the year 1899, 138 claims have been filed, making the total number of claims filed up to December 31, 1899, 220. Settlement has been effected in 59 cases during the year, making a total of 80 claims which have been settled, for which the sum of \$28,420 has been paid to the several claimants. Claims to the number of 47 have been disallowed during the year, in addition to 2 claims which had previously been disallowed, as not entitled to benefits under this Act. The remainder of the claims have been investigated, and offers have been made in 60 cases in which no agreement has yet been reached.

(14) CLAIMS FOR LOSS OF EMPLOYMENT.

Claims for damages may be brought by any resident of the town of West Boylston, employed by a corporation, partnership or individual, at the time when the plant of such corporation, partnership or individual was taken and work therein stopped on account of work in the Wachusett Reservoir, and who was obliged by such taking to seek employment elsewhere. The amount recoverable is limited to the actual damages suffered and not to exceed the sum of his wages for six months, at the rate paid to him for the six months prior to his loss of employment.

Claims to the number of 27 have been filed during the present year, making the total of such claims filed up to December 31, 1899, 92. Settlements have been made during the past year in 38 cases, and 15 claims have been disallowed. Offers have been made in 6 cases upon which no agreement has been reached. The sums paid to the employés with whom settlements have been made aggregate \$5,964. The total amount paid on account of this class of damages since the passage of the Act has been \$12,913.68.

(15) CLAIMS FOR DEPRECIATION OF REAL ESTATE.

Some progress has been made in the settlement of claims for injury to real estate not taken, but directly or indirectly decreased in value by the Metropolitan Water Act or the doings of the Board thereunder. The territory for which these damages are now payable comprises the whole of the town of West Boylston, the portion of the town of Boylston north of the proposed Wachusett Reservoir, a portion of the town of Clinton below the site of the reservoir, and that section of the town of Sterling in the vicinity of the reservoir.

It was not an easy matter for the Board or the claimants to determine with any degree of accuracy the damage which is to result from the operations of the Board to estates situated at a greater or less distance from the reservoir. The Board had desired to fix more exactly the margins of the reservoir, to determine somewhat more closely the location of new roads which were to take the place of existing roads that are to be discontinued, and to make progress upon the negotiations for the relocation of the Central Massachusetts Railroad.

By chapter 342 of the Acts of the year 1899, the time within which suits to recover on account of these claims might be brought was extended to July 1, 1901, so that no owners should be cut off from recovery on account of the claim by any delay in bringing suit.

These claims being of a class new to the law, no general rules have been laid down by the court upon which the Board may base awards for damages. The Board has not, however, desired to compel the claimants to bring suits, which might be carried to the Supreme Court, for the purpose of establishing such general rules, because they have felt that such action would be burdensome to the claimants, the larger part of whom are owners of small estates.

In a few cases, in which there seemed to be peculiar reasons for hastening a settlement, the Board made offers for compensation. During the latter part of the year, however, as considerable progress has been made in solving the preliminary questions of margins and roads, this class of cases has been taken up and a large number of offers have recently been made, the Board endeavoring, so far as possible, to consider the peculiar circumstances applicable to each case. Settlements have been effected in only 9 cases. These 9 cases do not include, however, 6 cases in which release of damages for depreciation has been made when compensation has also been given for lands taken.

III. WORK OF MAINTENANCE.

(1) OPERATION OF WORKS.

All of the various works of supply have been in operation during the past year. The Metropolitan Water Works have furnished water during the entire year, both for the low service and the high service, to all the municipalities in the District except the city of Medford and the towns of Arlington and Nahant, and the city of Newton and town of Hyde Park. The city of Medford furnished from its own works a part of its supply during the early part of the year, but at other times it has received all of its water from the Metropolitan Water Works. The town of Arlington was admitted into the District in January, 1899, and the low service of the town was supplied by the Metropolitan Works from June 30. The high service also will be supplied beginning with January 3, 1900. The

town of Nahant was admitted into the District in the latter part of the year 1898, and the pipe connections with the town were completed so that an entire supply was furnished from June 30, 1899. The city of Newton and the town of Hyde Park have made no application for water, their own supplies being so far sufficient for their purposes.

In order to supply the high service to a portion of the northern part of the District, it was necessary to make arrangements with the water departments of Chelsea, Malden, Somerville and Medford, and, for a portion of the summer, with the water department of the city of Everett and the Revere Water Company in Saugus, by which the pumping stations of those municipalities should be operated under the direction of the Board, and the cost of such operation was paid by the Board. It is expected, however, that upon the completion of the pumping station at Spot Pond early in the present year the assistance of these pumping stations will be no longer necessary, and all the pumping for this high service will be done by the Metropolitan Water Works. For a small district, however, in West Roxbury, the water is supplied by a small pumping station near Mt. Bellevue, belonging to the city of Boston, for the operation of which an arrangement for a term of years has been made with that city.

(2) SANITARY INSPECTION AND REGULATIONS.

Careful sanitary inspection has been continued in the watersheds which supply water to the District.

The number of premises inspected has been 974 in the Sudbury and Cochituate watersheds. One hundred and forty-six cases have been remedied by sewer connections and 9 by other means. Forty-nine cases have been partially remedied, and 141 cesspools have been superseded by sewer connections. Many other cases of pollution of various kinds have been abated.

The camps of the contractors, as well as other buildings where laborers have been housed, have been regularly visited by medical inspectors as well as by sanitary inspectors, in order to insure suitable sanitary conditions and to prevent contamination to the water from infectious diseases.

Under section 24 of the Metropolitan Water Act, the State Board of Health was authorized and required to make rules and regulations for the sanitary protection of all waters used by the Metropolitan

Water Board for a water supply. Such rules were adopted by the State Board of Health on June 1, 1899, and the rules are given in Appendix No. 5. These rules were likewise adopted by the Metropolitan Water Board on June 30, 1899, under the general power given the Board by section 10 of said Act.

It is provided in section 14 of these rules that no person, unless under special regulation or under a written permit from the Metropolitan Water Board, shall fish in, drive any animal into, or enter, in any boat or otherwise, upon any of the waters used as a source, or for the conveyance, storage or distribution of the water supply; and that no person shall enter upon any of the waters for the purpose of cutting or taking ice, without a written permit from the Board.

Special regulations have accordingly been made by the Board, under said section 14 of the rules, by which fishing and boating are, under limitations and conditions deemed proper for the prevention of pollution, permitted in the waters of Lake Cochituate, Farm Pond and Whitehall Reservoir, and fishing is permitted in the waters of Sandy Pond, the South Branch of the Nashua River above the temporary dam of the Metropolitan Water Board in Clinton, and from the highways and through the ice in the waters of the open channel of the Wachusett Aqueduct, Sudbury Reservoir, Framingham Reservoir No. 1, Framingham Reservoir No. 2, Hopkinton Reservoir and Ashland Reservoir. Provision is also made for the issuing, for limited periods, of special permits, giving the holders, subject to like limitations and conditions, permission to fish in Hopkinton Reservoir and in Ashland Reservoir from the shores, but not from the dam, and to fish through the ice, or from seven designated places situated at different points about the Sudbury Reservoir. It is further provided that special permits may be issued to owners of lands adjoining the margins of Framingham Reservoir No. 1 and Framingham Reservoir No. 2 to fish, subject to the above regulations, from the shores opposite their respective estates.

Fishing was generally permitted in Spot Pond during the last year, while the pond has been drawn down and the work of improvement has been going on, inasmuch as no water has been drawn during that time for the purposes of water supply. When the pond is used as a distributing reservoir such use of the pond will hardly

be consistent with the purposes of affording pure water, and consequently such further permission will be suspended.

Special regulations are in process of preparation under rule 15 of the rules of the State Board of Health, for the cutting and taking of ice from different reservoirs and water courses.

Bathing in any of these waters is absolutely prohibited by the rules of the State Board of Health, and bathing in a pond, the water of which is used for the purpose of domestic water supply for a city or town, is by statute punishable by fine.

It has been the policy of the Board not to make any more stringent or restrictive regulations than seemed to be required for the proper protection of the various sources of supply.

(3) THE YEAR'S WATER SUPPLY.

The supply of water received from the various sources of the Metropolitan System during the entire year has been unusually small. The records on the Sudbury watershed, which have been kept since the year 1875, show a smaller rainfall for the last nine months of the year than ever before in the corresponding months, and a smaller yield of water in the last eight months of the year than that of any eight consecutive months since the Sudbury records have been kept.

After corrections have been made for evaporation from the storage reservoirs and on account of other varying circumstances, it appears that, while the entire yield of the watershed for five consecutive months in the year 1899 was the smallest ever known, the yield of the watershed for eight consecutive months was still smaller in the year 1880:

The rainfall, as recorded in the Sudbury watershed during the year 1899, was 37.21 inches, as against a rainfall of 55.88 inches in the preceding year in the same watershed, being 8.98 inches less than the average rainfall during the last twenty-five years.

During nearly all of the first half of the year the main supply of water for consumption was taken from the Sudbury Reservoir, which is principally supplied from the Nashua River. Between July 28 and November 6 a considerable amount of water was drawn from Lake Cochituate, but previous to and subsequent to this period the water was so affected by objectionable organisms that it could

not well be used. Considerable quantities were also drawn from Ashland and Hopkinton reservoirs during the latter half of the year.

After Spot Pond was drawn down the water acquired a disagreeable odor and taste, and could not be longer used.

There has been an average daily flow during the year from the Nashua River, through the Wachusett Aqueduct, of 62,975,000 gallons. The average daily flow through the Sudbury Aqueduct, which included the Nashua water, has been 84,776,000 gallons. The average daily flow in the Cochituate Aqueduct has been 4,665,000 gallons.

The necessities of the District, arising from the decreased yield of the sources of supply, have caused a decrease of the quantity of water held in storage by the various reservoirs, from 15,622,300,000 gallons on June 4, to 6,428,400,000 gallons at the end of the year.

(4) CONSUMPTION OF WATER.

The consumption of water in the cities and towns of the District which were supplied wholly or in part by the Metropolitan Water Works during the past year exceeded that of the previous year by 9,259,000 gallons daily, or 11.7 per cent.; 1.7 per cent. of this increase, however, was due to the additions made to the territory supplied, leaving an increase of 10 per cent. in the District as it existed the preceding year. A portion of this increase was due to the natural growth of the District and a part to the differences of the two years. In the earlier part of the year 1899, owing to the extreme cold, much water was wasted on account of its being permitted to flow in order to prevent the water in the pipes in houses from freezing. On the other hand, the summer was so exceedingly dry that an unusual amount of water was used for the sprinkling of lawns and other like purposes.

The consumption of water in the cities and towns of the District which were supplied wholly or in part was, during the year 1899, 88,533,000 gallons daily, of which 87,143,000 gallons per day were supplied by the Metropolitan Works, and 1,390,000 gallons per day from local sources. The consumption of water per inhabitant in the district supplied was 110 gallons per day, — an increase of 7 gallons per day for each inhabitant.

It is the purpose of the Board to make, at as early a date as possible and as soon as more pressing duties will permit, a careful investigation into the use, or rather the misuse, and waste of water, in order to determine whether proper measures for the prevention of misuse or waste are either possible or feasible in the future.

(5) QUALITY OF WATER.

The quality of the water supplied to the District has continued to improve. This improvement is determined not only by the analyses and examinations which are made by the State Board of Health, but also by the various examinations and tests which are made, both regularly and in special cases, by the Board.

The improvement has been largely effected not only by the operations which have been carried on for the prevention of various sources of pollution and by the drainage of swamps and improvement of other sources of supply, but more especially by the introduction of the better water from the Nashua River, and by the means for enlarged storage which have already been provided.

The quality of the water which will be supplied to the District will undoubtedly vary from time to time, owing to the growths of certain disagreeable but not unwholesome organisms, which frequently come suddenly and as mysteriously disappear, and which cannot be wholly avoided. The measures which have been taken to prevent the growth of these organisms have been to a considerable extent successful.

The number of persons employed in the maintenance force at the end of the year 1899 was 134. This number, however, does not include those engineers, a part only of whose time was given to maintenance, nor does it include from 19 to 22 men who are employed in the pumping stations of the cities and towns whose operation has been temporarily carried on at the expense of the Board.

The following is a summary of the expenditures for maintenance and operation :—

	For the Year ending December 31, 1899.
Temporary dam and gate-house at site of the Wachusett Dam, the Wachusett Aqueduct from Clinton to Southborough, and the pumping station, filter-beds, etc., of the Clinton sewerage system,	\$9,285 22
The Sudbury, Ashland, Hopkinton, Framingham, Lake Cochituate and other reservoirs, the Sudbury and Cochituate aqueducts, the Pegan filters, the biological laboratory and other work in the Sudbury system,	67,221 95
Pumping at Chestnut Hill, Chelsea, Somerville, Spot Pond, West Roxbury and elsewhere, care of reservoirs and pipe lines, and other work in the distribution system,	113,808 70
Administration, supervision, taxes and other general expenses, .	18,806 96
Total,	\$209,122 83

IV. ADMISSION OF OTHER MUNICIPALITIES INTO THE DISTRICT.

The Metropolitan Water District was made by the Act to comprise the cities of Boston, Chelsea, Everett, Malden, Medford, Newton and Somerville, and the towns of Belmont, Hyde Park, Melrose (now a city), Revere, Watertown and Winthrop.

The city of Quincy and the town of Nahant had, in accordance with the provisions of the Act, been admitted into the District prior to the past year; arrangements had also been effected for supplying water to the town of Swampscott, which is situated beyond the ten-mile limit prescribed in the Act.

The town of Arlington made application for admission into the District on November 28, 1898, and was formally admitted on January 31, 1899. Under the arrangement effected, the town paid the sum of \$15,000 in cash, and in addition transferred to the Board property of an estimated value of \$15,000. The property so transferred consisted of the iron stand-pipe belonging to the water works of the town, together with the land upon which the stand-pipe stands, the pipes and other portions of the works therein, with the right of access thereto, and also the ten-inch cast-iron water pipes located in the town of Lexington and extending for a distance of nearly half a mile from the boundary line between

the towns of Lexington and Arlington to a point opposite the old pumping station of the Arlington water works, in Lexington. The town also granted to the Board the right to use, in common with the town of Arlington, the water pipes belonging to the town, so far as necessary and proper for the purpose of conveying water from the pumping station to be erected in the town by the Metropolitan Water Board to the stand-pipe, and for conveying the water from the stand-pipe or from the new pumping station to the boundary line between the towns of Lexington and Arlington.

Water was supplied for the low service of Arlington on June 30, and the works for the supply of the high service are so far finished that the entire town will be supplied after January 3, 1900.

Representatives of other towns have been in conference at times during the year with regard to admission of these towns into the District, but no formal arrangements for their admission have yet been perfected.

V. FINANCIAL STATEMENT.

! (1) RECEIPTS FROM WATER LOANS AND OTHER SOURCES.

The total receipts, on account of the Metropolitan Water Act, to December 31, 1899, amount, exclusive of premiums, to \$20,108,-334.53. These receipts, together with the fund available on January 1, 1900, are as follows:—

From sale of bonds,	\$20,000,000 00
From the town of Nahant, on admission to the District, . .	20,000 00
From the town of Arlington, on admission to the District, . .	15,000 00
From the town of Swampscott, on account of supplying water, .	20,645 84
From sale of water to water companies,	5,080 38
From rents, real estate and miscellaneous sources,	47,608 31
	<hr/>
	\$20,108,334 53
Distributed back to cities and towns in District, as provided in section 3 of the Metropolitan Water Act,	60,731 22
	<hr/>
	\$20,047,603 31
Amount approved for payment by Board to December 31, 1899, .	18,333,861 52
	<hr/>
Balance January 1, 1900,	\$1,713,741 79

If to this balance is added the sum of \$58,010.22, for bills, pay rolls, etc., sent to the Auditor in December, but not placed by him on warrant for payment until January, 1900, and the further sum of \$6.75 on warrants of the year 1896, which has never been called for, the result will be \$1,771,758.76, which is the balance reported available in the treasury on January 1, 1900.

The Treasurer of the Commonwealth was authorized by the Metropolitan Water Act to issue from time to time, on the request of the Board, negotiable bonds, in the name and behalf of the Commonwealth, to an amount not exceeding \$27,000,000, such bonds to be designated the "Metropolitan Water Loan," and to be payable in not less than thirty years, nor more than forty years.

The following is a statement of the bonds sold by the Treasurer to December 31, 1899:—

DATE.	Bonds Sold.	Rate (Per Cent.).	Time (Years).	Price.	Premiums.
1895, . . .	\$2,225,000	3½	40	\$110 67	\$237,407 50
1896, . . .	2,775,000	3½	40	110 67	296,092 50
1896, . . .	2,000,000	3½	39	106 76268	135,253 60*
1897, . . .	6,000,000	3½	38½	107 82	469,300 00
1898, . . .	2,000,000	3½	40	113 176	263,520 00
1898, . . .	2,000,000	3½	40	112 877	257,540 00
1899, . . .	3,000,000	3	40	100 64	19,200 00
	\$20,000,000				\$1,678,213 60

* Including \$18,673.90 from readjustment of rate made by Treasurer in 1897.

The Treasurer of the Commonwealth was required to establish a sinking fund sufficient, with its accumulations, to extinguish the bonded debt at maturity. To this sinking fund there is required to be paid the premiums from the sales of the bonds and the proceeds from the operations of the Board, exclusive of those arising from sales of property, and such further amounts as the Treasurer may deem necessary for the payment of interest and of the principal at maturity.

The sinking fund so established amounted at the end of each year to sums as follows : —

December 31, 1895,	\$226,286 05
December 31, 1896,	699,860 70
December 31, 1897,	954,469 00
December 31, 1898,	1,416,374 29
December 31, 1899,	1,349,332 97

The interest paid on the Metropolitan Water Loan bonds being \$595,000, and the assessments being limited to \$500,000, less the rebate for water furnished by cities and towns from their own works, the excess of the former over the latter has been taken from the sinking fund, making it less than a year ago.

For the payment of the interest on the bonds issued by the Commonwealth, the sinking fund requirements and the expenses of maintenance and operation of the water works, annual assessments are made upon the various cities and towns constituting the Metropolitan Water District. There is apportioned each year to the city of Boston such proportion of the required amount as the valuation of that city of the preceding year bears to the total valuation of all the cities and towns in the District; except that there is included in the amount of such valuations only one-sixth of the total valuation of any city and town which has not reached the safe capacity of its sources of supply in a dry year, as determined by the Water Board, and has not made application to the Board for water. The remainder to be raised is assessed to the other cities and towns in the District, one-third in proportion to their respective valuations and two-thirds in proportion to their respective populations, including, however, only one-sixth of the total valuation and one-sixth of the total population of any city or town which has not reached the safe capacity of its sources of supply, or has not made application for water as aforesaid. A city or town, however, which is assessed on its full valuation and population, and which furnishes a part of its water supply from its own works, or receives a supply from a water company, is allowed and credited in its apportionment with a sum equal to \$12 for each million gallons of water so furnished, as determined by the Board. It was, however, provided by the Act that no such amount

should be apportioned until the year 1898; and in that year that the amount of \$300,000 only, together with such sums as had been expended by the State Board of Health in its investigations of a water supply for the Metropolitan Water District, should be assessed. In each succeeding year the said amount of \$300,000, and \$200,000 additional for each year thereafter, shall be so apportioned, until the entire amount required for the payment of interest, sinking fund requirements and expenses of maintenance and operation is reached, and thereafter such entire sum so required is to be so apportioned.

The total sum, therefore, assessable in the year 1899 was \$500,000, subject to the credits allowed the cities and towns furnishing water from their own sources. The total amount allowed the cities and towns so furnishing water, at the rate of \$12 per million gallons, furnished from June 1, 1898, to May 31, 1899, was divided among the cities and towns as follows:—

Arlington,	\$1,042 80	Revere,	\$1,662 00
Malden,	79 44	Watertown,	918 00
Medford,	2,723 52	Nahant,	436 32
Quincy,	3,729 60		
Belmont,	306 00	Total,	\$10,897 68

After deducting the above allowances, the net sums assessed, in accordance with the provisions of the Act, by the Treasurer of the Commonwealth upon the various cities and towns of the district, for the year 1899, were as follows:—

Arlington,	\$1,846 35	Belmont,	\$1,116 01
Boston,	411,861 54	Hyde Park,	758 55
Chelsea,	11,627 09	Melrose,	4,921 63
Everett,	7,146 75	Revere,	1,684 91
Malden,	11,500 91	Watertown,	2,537 79
Medford,	3,739 61	Winthrop,	1,990 08
Newton,	2,477 25	Nahant,	440 77
Quincy,	4,477 50		
Somerville,	20,975 58	Total,	\$489,102 32

The smaller sums assessed upon the city of Newton and the town of Hyde Park were owing to the fact that neither of these munic-

ipalities had reached the safe capacity of its sources, and consequently neither had made application for water.

The Metropolitan Water Act further provided that any city or town not originally included in the District, any part of which is within ten miles of the State House, should be admitted into the district, upon such payment of money as the Board should determine; that the Board should, on application, furnish water to any water company owning the water pipe system in any city or town within said ten miles, upon its assuming the assessments of such city or town, and making such payment of money as the Board should determine; and that the Board might furnish water to any other city or town or water company on a like payment of money. All such payments of money were required to be distributed to the cities and towns in the District in proportion to the total amount of the annual assessments theretofore paid by them respectively. Up to December 31, 1899, the sum of \$60,731.22 had been received from the following sources:—

Quincy, for admission to District,	\$5 00
Nahant, for admission to District,	20,000 00
Arlington, for admission to District,	15,000 00
Swampscott, for water furnished,	20,645 84
Revere Water Company, for water furnished,	4,839 70
Framingham Water Company, for water furnished,	240 68
Total,	<u>\$60,731 22</u>

At the close of the year 1899, the Treasurer paid back this amount of \$60,731.22 to the several cities and towns in the Metropolitan District, in sums as follows:—

Belmont,	\$128 70	Newton,	\$299 38
Boston,	51,650 90	Quincy,	579 94
Chelsea,	1,424 06	Revere,	246 38
Everett,	867 29	Somerville,	2,577 19
Hyde Park,	91 58	Watertown,	312 91
Malden,	1,331 87	Winthrop,	152 18
Melrose,	602 76		
Medford,	466 63	Total,	<u>\$60,731 22</u>

(2) GENERAL STATEMENT OF EXPENDITURES.

The following is a summary of the expenditures made by the Board in its various operations:—

	For the Year ending December 31, 1899.	From Beginning of Work, and ending December 31, 1899.
<i>Construction.</i>		
Wachusett Dam, Reservoir and Watershed,	\$857,677 82	\$3,326,318 46
Wachusett Aqueduct,	50,100 46	1,763,605 16
Sudbury Dam, Reservoir and Watershed,	178,926 24	3,094,993 42
Pipe lines and connections between Framingham Dams No. 3 and No. 1,	-	48,465 47
Pipe line across Rosemary valley,	108 93	23,142 98
Distribution system, \$948,448 86	-	3,425,301 47
Less value of pipes, valves, etc., purchased and sent to store yard in previous years, but transferred to works, and included in cost of same for current year, 25,698 86	922,850 00	-
Other work and operations:—		
Investigations of existing water works systems, and pay- ments on account of same,	3,033 51	5,044,726 23
Settlements on account of diversion of water and expenses connected with same, including Clinton sewerage system,	58,674 39	969,498 73
Investigations regarding high-level aqueduct,	7,804 86	7,804 86
Administration and general expenses,	23,143 63	121,269 12
Pipes, valves, etc., sent to store yard and not yet trans- ferred to works,	-	121,525 48
	\$2,102,319 84	\$17,966,551 38
<i>Maintenance.</i>		
Dam and aqueduct department,	\$9,285 22	\$15,331 60
Sudbury department,	67,221 95	124,400 26
Distribution department,	113,808 70	196,792 01
Administration, general supervision and taxes,	18,806 96	30,786 27
	\$209,122 83	\$367,310 14
Total expenditures,	\$2,311,442 67	\$18,333,861 52

(3) DETAILED FINANCIAL STATEMENT.

The Board herewith presents, in accordance with the Metropolitan Water Act, an abstract of its expenditures and disbursements, receipts, assets and liabilities for the year 1899 : —

(a) *Expenditures and Disbursements.*

The total amount of the expenditures and disbursements for the year beginning January 1, 1899, and ending December 31, 1899, is \$2,311,442.67; and the total amount from the time of the organization of the Board, July 19, 1895, to December 31, 1899, is \$18,333,861.52. The salaries of the Commissioners, and other expenses of administration, have been apportioned to the construction of the works and maintenance and operation of the same, and appear under each of those headings. The following is a division of the expenditures according to their general character : —

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1899.	From Beginning of Work, and ending December 31, 1899.
I. CONSTRUCTION OF WORKS, AND ACQUISITION BY PURCHASE OR TAKING.		
<i>Administration.</i>		
Commissioners,	\$11,600 00	\$57,910 27
Secretary and auditor,	4,900 00	24,073 13
Clerks and stenographers, . . .	4,090 09	18,691 62
Legal services,	-	2,359 00
Travelling,	205 15	1,115 97
Stationery and printing,	652 84	4,108 55
Postage, express and telegrams, .	222 77	1,082 78
Furniture and fixtures,	126 55	3,262 53
Alterations and repairs of buildings, .	85 26	2,490 55
Telephone, lighting, heating, water and care of buildings,	676 57	4,143 79
Miscellaneous expenses,	584 40	2,030 93
	\$23,143 63	\$121,269 12
<i>Engineering.</i>		
Chief engineer and department engineers,	\$19,688 58	\$90,332 99
Principal assistant engineers, . .	15,386 33	64,449 94
Engineering assistants,	110,965 20	457,952 35
Consulting engineers,	1,250 00	18,701 10
Inspectors,	24,744 84	114,052 74
<i>Amounts carried forward, . . .</i>	\$172,034 95	\$745,489 12
	\$23,143 63	\$121,269 12

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1899.		From Beginning of Work, and ending December 31, 1899.	
<i>Amounts brought forward, . . .</i>	\$172,034 95	\$23,143 63	\$745,489 12	\$121,269 12
<i>Engineering — Con.</i>				
Architects,	11,238 10		19,667 71	
Railroad and street car travel, . . .	3,818 29		15,131 71	
Wagon hire,	3,419 20		14,227 48	
Stationery and printing,	3,367 67		14,249 21	
Postage, express and telegrams, . . .	1,130 41		3,949 97	
Engineering and draughting instruments and tools,	913 49		14,982 66	
Engineering and draughting supplies, . . .	2,754 13		14,775 36	
Books, maps, and photographic supplies,	841 48		3,847 09	
Furniture and fixtures,	854 22		11,999 44	
Alterations and repairs of building, — main office,	177 39		3,291 35	
Alterations and repairs of building, — sub-offices,	272 66		744 29	
Telephone, lighting, heating, water and care of building, — main office, . . .	1,193 57		6,235 74	
Telephone, lighting, heating, water and care of building, — sub-offices, . . .	1,494 18		7,332 13	
Rent of offices and other buildings, . . .	164 00		2,499 28	
Field offices and sheds,	61 74		764 38	
Clinton office building,	—		9,866 87	
Unclassified supplies,	498 69		4,686 83	
Miscellaneous expenses,	1,082 65		5,806 23	
Reimbursement, city of Boston, . . .	—		69,918 69	
		205,316 82		969,465 54
<i>Construction.</i>				
Preliminary work (borings, soundings, test pits and other investigations) :—				
Advertising,	\$1,361 94		\$3,986 53	
Labor,	6,822 46		78,157 72	
Medical services, analyses, etc., . . .	—		621 33	
Travelling,	21 50		1,482 38	
Rent,	—		37 00	
Water rates,	—		2,077 30	
Freight and express,	18 86		410 21	
Jobbing and repairing,	—		404 67	
Tools, machinery, appliances and hardware supplies,	47 77		14,997 22	
Castings, ironwork and metals, . . .	12 38		132 52	
Iron pipe and valves,	—		2,925 11	
Blasting supplies,	—		36 73	
Paint and coating,	—		138 54	
<i>Amounts carried forward, . . .</i>	\$8,284 91	\$228,460 45	\$105,407 26	\$1,090,734 66

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1899.		From Beginning of Work, and ending December 31, 1899.	
<i>Amounts brought forward, . . .</i>	\$8,284 91	\$228,460 45	\$105,407 26	\$1,090,734 66
<i>Construction — Con.</i>				
<i>Preliminary work, etc. — Con.</i>				
Fuel, oil and waste,	-		547 93	
Lumber and field buildings, . . .	-		4,786 26	
Drain pipe,	-		40 80	
Brick, cement and stone,	-		223 19	
Sand, gravel and filling,	-		195 05	
Municipal and corporation work, .	-		44 07	
Unclassified supplies,	14 95		1,082 60	
Miscellaneous expenses,	30 00		239 69	
Reimbursement, city of Boston, .	-		55,404 63	
		8,329 86		167,971 48
<i>Contracts, Wachusett Reservoir : —</i>				
Joseph D. Gennaro, . . . Sect. 1,	-		\$11,870 95	
Neill McBride, Sect. 2,	-		12,067 11	
T. H. Riddle & Co., . . . Sect. 3,	\$13,737 90		52,456 96	
Neill Devine & Co., . . . Sect. 4 (in part),	-		3,450 11	
Newell & Snowling Construction Co., Sect. 4 (in part),	-		6,052 22	
Joseph D. Gennaro, . . . Sect. 4 (in part),	12,239 20		28,488 01	
Sundry bills under this contract,	7,824 15		7,824 15	
Moulton & O'Mahoney, . Sects. 4 and 6 (in part),	-		9,884 56	
Moulton & O'Mahoney, . Sect. 6 (in part),	2,894 83		2,894 83	
Moulton & O'Mahoney, excavating soil, Sect. 4,	82,709 00		82,709 00	
Newell & Snowling Construction Co., surfacing Boylston Street, Sect. 1,	11,869 83		11,869 83	
Asa Goddard, surfacing Boylston Street, Sect. 2,	11,368 95		11,368 95	
Thomas H. Gill, improving Lancaster Street, West Boylston, . . .	8,438 87		8,438 87	
Cenedella Bros., . . . Sect. 5 (in part), and excavating and re- filling westerly portion of North Dike,	42,578 99		42,578 99	
Peter J. O'Malley, building road, West Boylston and Sterling, . .	20,166 28		20,166 28	
Nawn & Brock, Sect. 6, and building easterly portion of North Dike,	41,185 35		41,185 35	
Busch Bros., building road, West Boylston and Boylston, . . .	19,770 63		19,770 63	
Busch Bros., Wachusett Dam, pre- liminary excavation and masonry,	13,747 43		13,747 43	
		288,531 41		386,824 23
<i>Amounts carried forward, . . .</i>		\$525,321 72		\$1,645,530 37

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1899.	From Beginning of Work, and ending December 31, 1899.
<i>Amounts brought forward, . . .</i>	<i>. . . \$525,321 72</i>	<i>\$1,645,530 37</i>
<i>Construction — Con.</i>		
Contracts, Wachusett Aqueduct: —		
E. D. Smith & Co., . . . Sect. 2,	—	\$128,720 11
E. D. Smith & Co., . . . Sect. 3,	—	242,601 06
Silvio Casparis, . . . Sect. 4,	—	114,167 77
Silvio Casparis, . . . Sect. 5,	\$1,900 00	100,579 99
Silvio Casparis, . . . Sect. 6,	2,600 00	148,053 49
Silvio Casparis, . . . Sect. 7,	—	128,802 72
Jones, Pollard & Co., . . . Sect. 8,	—	64,766 00
Silvio Casparis, . . . Sect. 9,	—	171,041 07
Silvio Casparis, . . . Sect. 10,	—	170,252 02
Moulton & O'Mahoney, . . . Sect. 11,	26,407 55	170,050 32
W. A. Murtfeldt Co., covering Assabet Bridge,	—	1,261 00
J. W. Bishop & Co., superstructure terminal chamber,	—	4,260 00
New England Granite Works, superstructure gaging man-hole,	—	1,584 00
	30,907 55	1,446,139 55
Contracts, Sudbury Reservoir: —		
Moulton & O'Mahoney, Sudbury Dam,	—	\$297,482 60
Auguste Saucier, . . . Sect. A,	—	62,183 11
Moulton & O'Mahoney, . . . Sect. B,	—	55,477 93
Malone & Strang, . . . Sect. C,	—	81,070 83
Auguste Saucier, . . . Sect. D,	—	41,567 41
Charles Linehan, . . . Sect. E,	—	32,802 86
Newell & Snowling, . . . Sect. F,	—	26,272 55
Charles Linehan, . . . Sect. G,	—	16,738 23
Moulton & O'Mahoney, . . . Sect. H,	—	34,486 72
Harry P. Nawn, . . . Sect. I,	—	70,343 26
Moulton & O'Mahoney, . . . Sect. J,	—	43,754 13
Blagen & Bush, . . . Sect. K,	—	56,167 62
Moulton & O'Mahoney, . . . Sect. L,	—	78,864 00
Harry P. Nawn, . . . Sect. M,	—	107,879 43
Thomas Nevins & Son, . . . Sect. N,	—	55,227 98
Washburn & Washburn, . . . Sect. O,	\$20,087 23	139,964 83
Sundry bills paid under this contract,	—	933 51
Harry P. Nawn, . . . Sect. P,	—	86,430 70
Washburn & Washburn, . . . Sect. Q,	19,542 49	125,706 29
Mignault & McGrain, Spillway Channel,	1,361 97	2,350 05
S. D. Hicks & Son, changing gutter, etc., at gate-house,	—	275 00
<i>Amounts carried forward, . . .</i>	<i>\$40,991 69 \$556,229 27</i>	<i>\$1,415,979 04 \$3,091,669 92</i>

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1899.		From Beginning of Work, and ending December 31, 1899.	
<i>Amounts brought forward, . . .</i>	\$40,991 69	\$556,229 27	\$1,415,979 04	\$3,091,669 92
<i>Construction—Con.</i>				
Contracts, Sudbury Reservoir— <i>Con.</i>				
Henry Parsons, iron fence, . . .	-		16,342 96	
John Berry, filter-beds, . . .	-		896 79	
Auguste Saucier, filter-beds, . . .	35,522 17		35,522 17	
Mignault & McGrain, settling reservoir, . . .	-		2,380 45	
Holbrook, Cabot & Daly, stone arch bridge, . . .	-		33,400 21	
N. Y., N. H. & H. R.R. Co., temporary bridge, . . .	-		6,387 80	
R. D. Wood & Co., sluice gates, . . .	-		4,918 06	
J. W. Bishop & Co., gate-house, . . .	-		17,437 92	
John Evans & Co., granite finial, . . .	-		350 00	
Holbrook, Cabot & Daly, circular dam, . . .	-		4,550 27	
Reimbursement, city of Boston, . . .	-		461,089 26	
		76,513 86		1,999,254 93
Contracts, Rosemary Siphon:—				
A. L. Norton & Co., pipe laying, . . .	-		\$4,194 04	
Sundry bills paid under this contract, . . .	\$5 10		792 59	
T. Tighe & Sons, teaming pipe, . . .	-		930 33	
		5 10		5,916 96
Contracts, Pipe Line, Dam No. 3 to Dam No. 1:—				
Harry P. Nawn, pipe laying, . . .	-		\$15,269 27	
L. F. Childs, teaming pipe, . . .	-		1,970 95	
		-		17,240 22
Contracts, Clinton Sewerage System:—				
Newell & Snowling Construction Co., . . . Sect. 1,	\$5,549 43		\$21,162 62	
O. Cunningham & Son, . . . Sect. 2,	-		10,041 15	
Sundry bills paid under this contract, . . .	33 26		4,235 43	
Chas. N. Taylor, . . . Sect. 2,	19,739 48		19,739 48	
Cutting, Bardwell & Co., superstructure pumping station, . . .	5,499 54		5,499 54	
Geo. F. Blake Mfg. Co., pumping engine and air pump, . . .	6,200 00		6,200 00	
		37,021 71		66,878 22
Contracts, distribution system:—				
Malone & McHale, . . . Sect. 1,	-		\$6,867 63	
Curnan & Hochstader, . . . Sect. 2,	-		39,517 92	
MacRitchie & Nichol, . . . Sects. 3 and 10,	-		40,507 71	
<i>Amounts carried forward, . . .</i>	-	\$669,769 94	\$86,893 26	\$5,180,960 25

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1899.	From Beginning of Work, and ending December 31, 1899.
<i>Amounts brought forward, . . .</i>	- \$669,769 94	\$86,893 26 \$5,180,960 25
<i>Construction—Con.</i>		
Contracts, distribution system— <i>Con.</i>		
C. A. & C. E. Trumbull, . Sect. 4,	-	6,741 42
Snyder & Williams, . . Sects. 4 and 11,	-	48,469 33
MacRitchie & Nichol, . Sect. 5,	-	44,066 34
Moore & Co & W. H. Ward, Sect. 6,	-	9,448 65
Dennis F. O'Connell, . Sect. 6,	-	16,644 84
C. H. Eglee Co., . . Sects. 6 and 8,	-	61,681 92
C. H. Eglee Co., . . Sects. 7 and 13,	-	34,054 41
E. W. Everson & Co., . Sect. 9,	-	17,750 30
Bruno & Salomone, . . Sect. 9,	-	5,971 25
H. A. Hanscom & Co., . Sects. 11 and 18,	-	35,503 40
A. W. Bryne Construction Co., Sect. 13,	-	26,063 89
Collins & Ham, . . . Sect. 14,	-	11,759 81
J. H. McKnight, . . . Sect. 15,	-	11,966 06
George Goodhue, . . . Sect. 16,	-	4,925 11
H. A. Hanscom & Co., . Sect. 16,	-	2,447 12
H. A. Hanscom & Co., . Sect. 17,	-	2,534 72
Collins & Ham, . . . Sect. 18,	-	10,868 97
Cheney & Trumbull, . Sect. 18,	-	2,561 65
E. W. Everson & Co., . Sect. 19,	-	36,842 54
Bruno & Salomone, . . Sect. 19,	-	5,788 38
H. A. Hanscom & Co., . Sect. 20,	4,883 59	30,673 90
Saucier & O'Brien, . . Sect. 21,	-	13,462 66
Bruno & Salomone, . . Sect. 23,	-	9,895 24
Samuel Frescoln, . . . Sect. 24,	-	8,892 10
E. W. Everson & Co., . Sect. 24,	-	5,050 36
Michael Russo, Sect. 25,	-	2,663 34
Mirick & Wentworth, . Sect. 26,	2,564 90	11,593 68
O'Rourke & Nelson, . . Sect. 27,	3,429 99	11,200 66
Bruno & Salomone, . . . Sect. 28,	9,435 26	9,435 26
H. A. Hanscom & Co., laying pipe, Arlington,	903 29	903 29
R. D. Wood & Co., iron pipe and special castings,	-	299,806 34
Warren Foundry and Machine Co., iron pipe,	-	260,457 72
McNeal Pipe and Foundry Co., iron pipe and special castings, . . .	29,660 83	422,609 16
Camden Iron Works, iron pipe, special castings and valves, . .	20,647 18	352,167 28
<i>Amounts carried forward, . . .</i>	\$71,625 04 \$669,769 94	\$1,921,794 36 \$5,180,960 25

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1899.		From Beginning of Work, and ending December 31, 1899.	
<i>Amounts brought forward, . . .</i>	\$71,525 04	\$669,769 94	\$1,921,794 36	\$5,180,960 25
<i>Construction — Con.</i>				
Contracts, distribution system — <i>Con.</i>				
Addyston Pipe and Steel Co., iron pipe,	-		30,473 48	
Chelmsford Foundry Co., cast iron frames and covers,	-		1,841 61	
Davis & Farnum Manufacturing Co., cast iron frames and covers,	-		998 04	
Howard-Harrison Iron Co., iron pipe,	-		156,628 28	
Coffin Valve Co., valves and sluice gates,	8,601 00		10,446 00	
Josiah H. Long, valves,	-		14,008 00	
Kennedy Valve Mfg. Co., valves,	-		11,390 00	
New Jersey Steel and Iron Co., steel work for valve chamber,	-		2,132 55	
New Jersey Steel and Iron Co., pipe bridge over Mystic River,	-		3,980 00	
New Jersey Steel and Iron Co., pipe bridge over Nashua River,	1,875 00		1,875 00	
Cheney & Trumbulls, pipe bridge over Mystic River,	-		3,570 28	
David H. Andrews, pipe bridge over Boston & Maine Railroad,	-		2,497 00	
Boston Bridge Works, pipe bridge over Boston & Albany Railroad,	-		1,500 00	
Pittsburg Bridge Co., pipe bridge over Boston & Maine Railroad,	-		3,097 00	
The E. P. Allis Co., Chestnut Hill high-service pumping engine,	34,200 00		85,500 00	
The W. H. Gallison Co., steam piping,	237 25		1,637 25	
C. A. Dodge & Co., addition to Chestnut Hill pumping station,	3,051 03		48,694 62	
Edward Kendall & Sons, iron work for pumping station,	-		3,199 32	
Lake Erie Boiler Works, Belpaire boiler, Chestnut Hill high-service pumping station,	-		13,650 00	
Brown Hoisting and Conveying Ma- chinery Co., hand travelling crane,	-		1,930 00	
Hugh Cairns, stone carving on pumping station,	-		214 00	
H. W. Johns Manufacturing Co., asbestos covering,	40 00		234 20	
New England Structural Co., steel work for valve chambers,	-		1,496 00	
New England Structural Co., travel- ling crane,	5,344 00		5,344 00	
C. H. Eglee Co., gate-house and connections, Spot Pond,	-		21,559 74	
<i>Amounts carried forward, . . .</i>	\$124,673 32	\$669,769 94	\$2,349,690 73	\$5,180,960 25

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1899.		From Beginning of Work, and ending December 31, 1899.	
<i>Amounts brought forward, . .</i>	\$124,873 32	\$669,769 94	\$2,349,690 73	\$5,180,960 25
<i>Construction — Con.</i>				
Contracts, distribution system — <i>Con.</i>				
T. W. Kinser & Sons, high-service reservoir, Middlesex Falls, . .	1,000 00		30,972 29	
Sundry bills under this contract, . .	-		5,066 19	
Nawn & Brock, completing high-service reservoir,	66,006 00		68,836 40	
Norcross Bros., Chestnut Hill low-service pumping station, . . .	122,688 40		139,379 62	
The Atlantic Works, sluice gates, . .	9,634 25		10,225 85	
The Atlantic Works, fire tube boilers,	5,240 00		5,240 00	
American Stoker Co., stokers on Belpaire boilers,	2,000 00		2,000 00	
The Fuel Economizer Co., fuel economizer,	1,643 00		1,643 00	
Charles E. Hall & Co., marble about pump well and staircase, Chestnut Hill pumping station, . .	190 00		190 00	
Lake Erie Boiler Works, vertical fire tube boilers,	16,537 50		16,537 50	
W. L. Clark & Co., gate-house, northern high-service reservoir, .	2,596 00		2,596 00	
W. L. Clark & Co., stable, Glenwood pipe yard,	14,500 00		14,500 00	
Lynn Stall Co., stable fittings, . .	200 00		200 00	
Westinghouse Electric and Mfg. Co., electric generators, . . .	1,000 00		1,000 00	
C. E. Trumbull, drainage system, Spot Pond,	24,099 75		24,099 75	
United States Cast Iron Pipe & Foundry Co., iron pipe, . . .	1,551 35		1,551 35	
Holly Manufacturing Co., Chestnut Hill low-service pumping engine,	13,650 00		13,650 00	
W. H. Ryan & Co., water-pipe boxes and siphon,	4,778 61		4,778 61	
McNeil Bros., high-service pumping station and gate-house, Spot Pond,	76,553 26		76,553 26	
Newell & Snowling Construction Co., . . . Spot Pond, Sect. 1,	34,780 10		34,780 10	
Moulton & O'Mahoney, Spot Pond, Sect. 2,	31,988 61		31,988 61	
Newell & Snowling Construction Co., . . . Spot Pond, Sect. 3,	10,680 72		10,680 72	
Moulton & O'Mahoney, Spot Pond, Sect. 4,	18,704 35		18,704 35	
P. H. Fitzgerald, . . . Spot Pond, Sect. 6,	29,949 10		29,949 10	
<i>Amounts carried forward, . .</i>	\$614,844 32	\$669,769 94	\$2,894,813 43	\$5,180,960 25

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1899.		From Beginning of Work, and ending December 31, 1899.	
<i>Amounts brought forward, . . .</i>	\$614,844 32	\$669,769 94	\$2,894,813 43	\$5,180,960 25
<i>Construction — Con.</i>				
Contracts, distribution system — <i>Con.</i>				
Baker & Judson, gate-chamber and connection, Chestnut Hill Reservoir,	13,827 54		13,827 54	
Brodhead Contracting Co., dams at Spot Pond,	26,057 41		26,057 41	
	\$654,729 27		\$2,934,698 38	
Deduct value of pipes, valves, etc., included in above list, since transferred to maintenance account, and shown on page 54,	192 76		2,820 89	
		654,536 51		2,931,877 49
<i>Additional work:—</i>				
Labor,	\$159,745 90		\$318,827 83	
Medical services, analyses, etc.,	104 50		599 60	
Travelling,	131 05		687 57	
Rent,	83 00		2,256 37	
Water rates,	128 46		195 95	
Freight and express,	4,087 26		5,920 78	
Jobbing and repairing,	2,056 73		4,778 60	
Tools, machinery, appliances, and hardware supplies,	16,745 97		36,479 92	
Castings, ironwork and metals,	12,013 24		26,133 12	
Iron pipe and valves,	12,514 07		27,413 10	
Blasting supplies,	239 51		771 75	
Paint and coating,	336 24		2,847 85	
Fuel, oil and waste,	1,081 38		2,943 30	
Lumber and field buildings,	28,633 71		52,324 30	
Drain pipe,	919 39		2,745 56	
Brick, cement and stone,	3,906 10		8,420 50	
Sand, gravel and filling,	292 98		2,620 65	
Municipal and corporation work,	6,680 19		58,717 19	
Police service,	11,348 54		84,811 46	
Sanitary inspection,	600 00		4,478 61	
Judgments,	—		1,000 00	
Unclassified supplies,	1,932 57		4,365 29	
Miscellaneous expenses,	2,161 40		4,671 56	
Reimbursement, city of Boston,	—		21,765 87	
		265,792 19		675,776 73
<i>Legal and expert:—</i>				
Legal services,	—		\$3,368 82	
Expert services,	—		475 87	
Court expenses,	—		57 86	
Miscellaneous expenses,	—		33 35	
				3,935 90
<i>Amounts carried forward,</i>		\$1,590,098 64		\$8,792,550 37

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1899.	From Beginning of Work, and ending December 31, 1899.
<i>Amounts brought forward, . . .</i>	<i>\$1,590,098 64</i>	<i>\$8,792,550 37</i>
<i>Real Estate.</i>		
Legal and expert:—		
Legal services,	—	\$4,736 31
Conveyancer and assistants, . . .	\$11,824 81	59,238 99
Experts,	188 50	14,017 90
Appraisers,	4,736 45	10,003 64
Court expenses,	766 26	800 98
Counsel expenses,	—	43 25
Conveyancing supplies,	199 99	2,534 18
Conveyancing expenses,	741 21	3,207 27
Miscellaneous expenses,	363 54	746 45
Reimbursement city of Boston, . .	3,154 75	15,021 25
Settlements, made by Board, . . .	435,370 08	2,522,596 02
Settlements, reimbursement, city of Boston,	—	531,606 00
Judgments,	13,857 08	14,490 68
Taxes and tax equivalents, . . .	18,165 55	48,057 42
Care and disposal,	4,255 65	9,057 62
	493,623 87	3,236,157 96
<i>Damages to Real Estate not taken, to Business, and on Account of Loss of Wages.</i>		
Legal and expert services,	—	\$1,130 67
Settlements,	\$17,059 00	44,108 68
	17,059 00	45,239 35
<i>Claims on Account of Diversion of Water.</i>		
Legal and expert:—		
Legal services,	—	\$3,749 98
Expert services,	\$1,112 75	11,572 17
Miscellaneous expenses,	80 13	281 10
Settlements,	—	849,350 00
	1,192 88	864,953 25
<i>Purchase of Existing Water Works.</i>		
Legal and expert:—		
Legal services,	—	\$1,835 84
Expert services,	\$87 50	87 50
Miscellaneous expenses,	257 95	727 11
Settlements,	—	5,025,000 00
	345 45	5,027,650 45
<i>Amounts carried forward, . . .</i>	<i>\$2,102,319 84</i>	<i>\$17,966,551 38</i>

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1899.	From Beginning of Work, and ending December 31, 1899.
<i>Amounts brought forward, . . .</i>	<i>\$2,102,319 84</i>	<i>\$17,966,551 38</i>
II. MAINTENANCE AND OPERATION OF WORKS.		
Administration :—		
Commissioners,	\$2,400 00	\$4,800 00
Secretary, auditor and assistants, .	4,944 50	8,804 50
Postage, printing, stationery and other supplies,	396 50	630 48
Travelling,	179 83	179 83
Telephone, heating, lighting and care of building,	503 64	763 42
Miscellaneous expenses,	145 42	146 72
Supervision and general superintendence :—		
Chief engineer and department engineers,	5,155 00	10,821 67
Engineering and clerical assistants,	6,031 19	11,308 97
Postage, printing, stationery and office supplies,	749 49	1,154 36
Telephone, heating, lighting and care of offices,	977 21	1,632 54
Travelling and incidental expenses,	580 22	1,079 89
Alterations and repairs of buildings,	-	873 02
Miscellaneous expenses,	98 11	293 16
Pumping service :—		
Labor,	27,959 65	52,411 42
Fuel,	18,950 09	36,492 29
Oil, waste and packing,	835 48	1,583 76
Repairs and renewals,	1,715 41	3,689 45
Small supplies and expenses, . .	1,515 68	3,229 84
Pumping by municipalities, . . .	29,505 11	32,058 80
Superintendents and assistant superintendents,	2,403 09	5,652 69
Engineering assistants,	7,973 93	12,220 94
Laboratory force,	2,724 00	5,363 92
Sanitary inspectors,	2,500 00	4,867 72
Recording and scientific instruments and supplies,	147 63	980 07
Labor and teaming,	60,202 14	113,421 63
Tools, machinery and appliances, .	1,580 87	4,030 49
Lumber and hardware supplies, .	1,181 59	2,509 19
Jobbing and repairing,	1,686 95	3,367 35
Travelling,	2,658 56	3,621 79
Horses, vehicles and stable expenses,	2,362 47	5,936 65
Fuel,	1,384 98	2,928 10
Municipal and corporation work, .	1,512 54	1,712 54
<i>Amounts carried forward, . . .</i>	<i>\$190,861 28 \$2,102,319 84</i>	<i>\$338,567 20 \$17,966,551 38</i>

GENERAL CHARACTER OF EXPENDITURES.	For the Year ending December 31, 1899.	From Beginning of Work, and ending December 31, 1899.
<i>Amounts brought forward, . . .</i>	\$190,861 28 \$2,102,319 84	\$338,567 20 \$17,966,551 38
MAINTENANCE, ETC. — Con.		
Alterations and repairs of buildings, . . .	-	402 97
Settlements,	1,000 00	1,000 00
Taxes,	7,954 68	11,618 66
Contracts and agreements,	4,059 43	4,059 43
Contracts for pipes, valves, etc., originally charged to construction, since transferred to maintenance (included in list, pages 48, 49, 50 and 51),	192 76	2,820 89
Unclassified supplies,	3,631 90	6,223 78
Miscellaneous expenses,	1,422 78	2,717 21
	209,122 83	367,310 14
Total expenditures,	\$2,311,442 67	\$18,333,861 52

The following division will show the costs of the different works : —

EXPENDITURES FOR DIFFERENT WORKS.	For the Year ending December 31, 1899.	From Beginning of Work, and ending December 31, 1899.
General administration applicable to all parts of the construction and acquisition of the works,	\$23,143 63	\$121,269 12
<i>Wachusett Dam and Reservoir.</i>		
Wachusett Dam : —		
Engineering,	\$10,487 75	\$47,029 40
Preliminary work,	231 82	24,073 56
Contracts,	10,350 22	10,350 22
Additional work,	2,047 73	2,631 32
Contracts, temporary works,	4,027 44	11,394 81
Additional work, temporary works,	21,415 35	94,501 81
North Dike, engineering,	17,852 01	49,532 82
preliminary work,	236 97	27,815 83
contracts,	75,664 53	100,676 50
additional work,	53,975 43	69,876 28
South Dike, engineering,	51 25	1,193 20
preliminary work,	-	2,485 98
additional work,	19 00	55 00
Removal of soil, engineering,	19,082 62	49,810 68
preliminary work,	849 57	28,682 14
contracts,	120,340 99	158,670 94
additional work,	6,306 24	8,881 33
<i>Amounts carried forward,</i>	<i>\$342,938 92 \$23,143 63</i>	<i>\$687,561 82 \$121,269 12</i>

EXPENDITURES FOR DIFFERENT WORKS.	For the Year ending December 31, 1899.		From Beginning of Work, and ending December 31, 1899.	
<i>Amounts brought forward, . . .</i>	\$342,938 92	\$23,143 63	\$687,561 82	\$121,269 12
<i>Wachusett Dam and Reservoir — Con.</i>				
Relocation of railroads :—				
Engineering,	1,324 78		5,898 55	
Preliminary and additional work, .	—		116 87	
Roads and bridges, engineering, .	20,092 44		41,122 65	
preliminary work,	222 29		721 80	
contracts, roads, .	78,778 46		113,758 32	
additional work, .	20,719 11		29,166 43	
Real estate :—				
Engineering,	4,495 00		42,512 80	
Legal, conveyancing and expert, .	15,570 37		69,606 65	
Mill property and water rights, .	199,700 00		1,310,700 00	
Other property for reservoir and margins :—				
Clinton,	43,496 55		160,238 02	
Boylston,	39,205 30		163,685 30	
West Boylston,	42,275 00		560,695 00	
Sterling,	1,800 00		23,145 75	
Outlying property :—				
Clinton,	—		5,559 00	
Boylston,	40 00		410 00	
West Boylston,	—		2,030 00	
Lancaster,	5,890 66		11,678 66	
Taxes and tax equivalents, . . .	18,165 55		41,270 72	
Care and disposal,	4,204 05		8,286 17	
Damages in West Boylston :—				
Real estate, not taken,	2,400 00		2,775 00	
Decrease of business,	8,535 00		28,260 00	
Loss of wages,	5,964 00		12,913 68	
Damages in Sterling :—				
Decrease of business,	160 00		160 00	
Legal and expert (except in real estate),	—		1,130 67	
		855,977 48		3,323,403 86
<i>Improving Wachusett Watershed.</i>				
Engineering,	\$580 49		\$1,754 75	
Preliminary work,	—		40 00	
Additional work,	1,109 85		1,109 85	
Legal, conveyancing and expert, .	10 00		10 00	
		1,700 34		2,914 60
<i>Wachusett Aqueduct.</i>				
Engineering,	\$2,813 94		\$161,255 11	
Preliminary work,	—		3,545 79	
<i>Amounts carried forward, . . .</i>	\$2,813 94	\$880,821 45	\$164,800 90	\$3,447,587 58

EXPENDITURES FOR DIFFERENT WORKS.	For the Year ending December 31, 1899.		From Beginning of Work, and ending December 31, 1899.	
<i>Amounts brought forward, . . .</i>	\$2,813 94	\$880,821 45	\$164,800 90	\$3,447,587 58
<i>Wachusett Aqueduct — Con.</i>				
Contracts, tunnel,	-		342,005 80	
covered masonry,	4,500 00		859,466 21	
Assabet bridge,	-		66,239 46	
terminal chamber,	-		8,641 60	
open channel,	26,407 55		170,050 32	
Additional work,	3,594 77		80,297 99	
Legal, conveyancing and expert,	602 60		10,882 89	
Real estate :—				
Property and easements :—				
Berlin,	-		10,357 50	
Clinton,	500 00		18,200 00	
Northborough,	6,020 00		23,301 40	
Marlborough,	850 00		2,807 50	
Southborough,	4,760 00		5,775 00	
Taxes, care and disposal,	51 60		678 59	
		50,100 46		1,763,505 16
<i>Sudbury Dam and Reservoir.</i>				
Dam, engineering,	\$728 89		\$45,965 73	
preliminary work,	-		4,766 88	
contracts, core wall,	-		88,773 86	
embankment,	-		127,574 66	
masonry section,	-		327,027 27	
gate house super-structure,	-		18,062 92	
sluice gates and iron work,	-		4,918 06	
spillway channel,	1,361 97		2,350 05	
additional work,	1,133 02		28,970 90	
Reservoir, engineering,	2,318 49		126,410 64	
preliminary work,	-		51,413 54	
contracts, removal of soil and deepening,	39,029 19		1,158,945 78	
roads and rail-roads,	600 53		217,245 90	
regulating dam,	-		4,550 27	
additional work,	2,536 68		62,073 82	
Legal, conveyancing and expert,	3,930 24		21,972 67	
Real estate, property,	27,495 15		619,343 43	
taxes, care and disposal,	-		6,879 56	
		79,134 16		2,917,245 94
<i>Protection of Sudbury Supply.</i>				
Engineering,	\$8,413 44		\$14,831 70	
Preliminary work,	72 00		1,377 83	
Contracts,	35,522 17		49,806 16	
<i>Amounts carried forward, . . .</i>	\$44,007 61	\$1,010,056 07	\$66,015 69	\$8,128,338 68

EXPENDITURES FOR DIFFERENT WORKS.	For the Year ending December 31, 1899.		From Beginning of Work, and ending December 31, 1899.	
<i>Amounts brought forward, . . .</i>	\$44,007 61	\$1,010,056 07	\$66,015 69	\$8,128,338 68
<i>Protection of Sudbury Supply — Con.</i>				
Additional work,	1,411 22		1,502 49	
Legal, conveyancing and expert, . .	153 00		236 30	
Real estate,	—		37,626 32	
		45,571 83		105,380 80
<i>Improving Sudbury Watershed.</i>				
Engineering,	\$9,434 31		\$15,929 00	
Preliminary work,	831 74		831 74	
Additional work (day work), . . .	35,631 05		45,208 69	
Legal, conveyancing and expert, . .	516 15		725 75	
Real estate,	7,807 00		9,671 50	
		54,220 25		72,366 68
<i>Pipe Lines and Connections between Framingham Dams No. 3 and No. 1.</i>				
Engineering,	—		\$2,528 19	
Preliminary work,	—		239 58	
Contracts,	—		44,415 28	
Additional work,	—		1,282 42	
		—		48,465 47
<i>Pipe Line across Rosemary Valley.</i>				
Engineering,	\$70 44		\$2,010 12	
Contracts,	5 10		20,426 91	
Additional work,	33 39		681 33	
Preliminary work,	—		24 62	
		\$108 93		23,142 98
<i>Distribution System.</i>				
Low service:—				
Pipe lines and connections:—				
Engineering,	\$5,308 62		\$91,647 98	
Preliminary work,	37 90		8,463 24	
Contracts, Sect. 1,	11,074 64		35,065 12	
			179,386 91	
			32,678 13	
			202,087 98	
			49,142 93	
			136,869 77	
			131,860 23	
			139,674 10	
			108,745 62	
			20,345 99	
			143,553 52	
			14,657 50	
			36,803 01	
<i>Amounts carried forward, . . .</i>	\$57,789 54	\$1,109,957 08	\$1,330,982 06	\$8,377,694 61

EXPENDITURES FOR DIFFERENT WORKS.	For the Year ending December 31, 1899.	From Beginning of Work, and ending December 31, 1899.
<i>Amounts brought forward, . .</i>	\$57,789 54 \$1,109,957 08	\$1,330,982 06 \$8,377,694 61
<i>Distribution System — Con.</i>		
Low service — <i>Con.</i>		
Pipe lines and connections — <i>Con.</i>		
Additional work,	4,048 78	41,233 95
Additional work, . . Sect. 1,	2,211 44	3,791 83
Sect. 2,	88 25	3,242 43
Sect. 3,	-	39 55
Sect. 4,	102 26	11,037 61
Sect. 5,	-	13 70
Sect. 6,	79 50	1,951 43
Sect. 7,	14 98	4,432 09
Sect. 8,	2 00	4,144 62
Sect. 9,	169 87	2,556 63
Sect. 10,	-	10 69
Sect. 11,	1,208 33	4,971 84
Sect. 12,	-	750 00
Sect. 28,	1,972 31	1,972 31
Pumping station, Chestnut Hill:—		
Engineering,	11,168 53	31,217 37
Preliminary work,	-	146 10
Contracts, building,	130,646 88	148,469 22
engines,	13,650 00	13,650 00
boilers,	6,883 00	6,883 00
lighting and heating,	1,000 00	1,000 00
Additional work,	903 17	4,918 44
Additional work, building,	615 96	615 96
engines,	44 65	44 65
boilers,	172 94	172 94
pipings,	2,974 37	2,974 37
Reservoir (Spot Pond):—		
Engineering,	39,559 12	54,465 25
Preliminary work,	5,045 78	6,243 57
Contracts, earthwork,	117,972 10	117,972 10
core wall,	20,667 17	20,667 17
gate-houses and inlets,	24,642 50	43,447 52
drainage system,	23,160 17	23,160 17
Additional work,	17,577 61	22,789 01
Additional work, earthwork Sect. 5,	42,711 52	42,711 52
Gate-house and connections, Chestnut Hill Reservoir:—		
Engineering,	2,869 90	2,869 90
Preliminary work,	7 13	7 13
<i>Amounts carried forward, . .</i>	\$529,959 71 \$1,109,957 08	\$55,556 13 \$8,377,694 61

EXPENDITURES FOR DIFFERENT WORKS.	For the Year ending December 31, 1899.		From Beginning of Work, and ending December 31, 1899.	
<i>Amounts brought forward, .</i>	\$529,959 71	\$1,109,957 08	\$1,955,556 13	\$8,377,694 61
<i>Distribution System — Con.</i>				
Low service — <i>Con.</i>				
Gate-house and connections, Chestnut Hill Reservoir — <i>Con.</i>				
Contracts,	38,179 45		38,179 45	
Additional work,	897 63		897 63	
Real estate,	59,627 50		65,514 00	
Legal, conveyancing and expert, .	368 50		2,624 22	
Northern high service —		629,032 79		2,062,771 43
Pipe lines and connections :—				
Engineering,	\$4,340 71		\$35,844 02	
Preliminary work,	12 39		1,588 30	
Contracts,	6,694 11		81,194 97	
Sect. 13,				
Sect. 14,	—		39,682 97	
Sect. 15,	68 56		41,442 53	
Sect. 16,	91 98		23,896 06	
Sect. 17,	113 72		7,044 19	
Sect. 18,	6 91		52,500 87	
Sect. 26,	9,263 95		41,164 70	
Sect. 27,	3,585 72		27,729 37	
Additional work,	3,880 99		9,533 42	
Additional work,				
Sect. 13,	788 14		950 71	
Sect. 14,	99 00		2,890 98	
Sect. 15,	163 15		631 63	
Sect. 16,	86 28		397 58	
Sect. 17,	17 34		123 74	
Sect. 18,	72 16		1,101 99	
Sect. 26,	2,947 01		3,011 90	
Sect. 27,	3,861 24		3,906 87	
Pumping station at Spot Pond :—				
Engineering,	12,277 52		16,311 30	
Preliminary work,	—		37 00	
Contracts, building,	87,289 29		87,322 77	
boilers,	16,537 50		16,537 50	
Additional work,	134 89		995 95	
Additional work, building,	880 02		880 02	
engines,	2,761 40		2,761 40	
boilers,	149 66		149 66	
piping,	941 02		941 02	
Reservoir in Middlesex Fells :—				
Engineering,	7,118 85		19,481 10	
Preliminary work,	—		889 65	
Contracts,	73,022 00		111,562 07	
Additional work,	1,198 85		2,843 50	
<i>Amounts carried forward, .</i>	\$238,404 36	\$1,738,989 87	\$635,349 74	\$10,440,466 04

EXPENDITURES FOR DIFFERENT WORKS.	For the Year ending December 31, 1899.		From Beginning of Work, and ending December 31, 1899.	
<i>Amounts brought forward, . . .</i>	\$238,404 36	\$1,738,989 87	\$635,349 74	\$10,440,466 04
<i>Distribution System — Con.</i>				
Northern high service — <i>Con.</i>				
Real estate,	—		13,200 00	
Legal, conveyancing and expert, . .	61 00		513 55	
		238,465 36		649,063 29
Southern high service :—				
Pipe lines and connections :—				
Engineering,	\$1,610 35		\$35,807 85	
Preliminary work,	—		1,928 26	
Contracts,	—		171,882 10	
Sect. 19,	—			
Sect. 20,	4,910 40		110,437 30	
Sect. 21,	—		48,194 67	
Sect. 23,	—		42,594 76	
Sect. 24,	77 51		37,680 35	
Sect. 25,	—		9,255 15	
Additional work,	3,239 48		23,252 19	
Additional work,	326 52		5,063 75	
Sect. 19,	630 93		1,373 45	
Sect. 21,	181 69		1,588 44	
Sect. 22,	81 00		81 00	
Sect. 23,	218 51		1,028 03	
Sect. 24,	60 83		3,192 75	
Sect. 25,	269 32		609 28	
Pumping station, Chestnut Hill :—				
Engineering,	2,690 66		14,574 15	
Preliminary work,	—		96 93	
Contracts, building,	3,241 03		62,365 95	
engines,	34,200 00		85,500 00	
boilers,	2,000 00		15,650 00	
piping,	277 25		1,871 45	
travelling crane,	—		1,930 00	
Additional work,	3,144 99		8,737 71	
Reservoir in Quincy :—				
Engineering,	1,591 06		2,898 37	
Preliminary work,	—		91 85	
Contracts, reservoir,	275 40		275 40	
Additional work,	—		95 00	
Real estate,	3,340 00		7,765 00	
Legal, conveyancing and expert, . .	244 00		2,452 84	
		62,610 93		688,273 88
Northern extra high service :—				
Engineering,	\$1,279 27		\$1,487 38	
Preliminary work,	37 75		37 75	
<i>Amounts carried forward, . . .</i>	\$1,317 02	\$2,040,066 16	\$1,525 13	\$11,777,803 21

EXPENDITURES FOR DIFFERENT WORKS.	For the Year ending December 31, 1899.		From Beginning of Work, and ending December 31, 1899.	
<i>Amounts brought forward, .</i>	\$1,317 02	\$2,040,066 16	\$1,525 13	\$11,777,803 21
<i>Distribution System — Con.</i>				
Northern extra high service — <i>Con.</i>				
Pipe lines and connections:—				
Contracts,	455 50		455 50	
Additional work,	242 86		242 86	
Pumping station in Arlington:—				
Additional work, building, . .	42 24		42 24	
engines,	2,835 95		2,835 95	
boilers,	17 25		17 25	
pipings,	87 79		87 79	
Real estate,	2,400 00		2,400 00	
Legal, conveyancing and expert, .	31 65		31 65	
		7,430 26		7,638 37
Southern extra high service:—				
Engineering,		61 00		316 66
Glenwood pipe yard:—				
Engineering,	\$523 76		\$523 76	
Additional work,	24 76		24 76	
Contracts, buildings,	10,300 00		10,300 00	
Real estate,	-		6,389 32	
		10,848 52		17,237 84
<i>Diversion of Water, South Branch of Nashua River.</i>				
Engineering,	\$1,369 76		\$14,345 86	
Legal, conveyancing and expert, .	1,245 33		17,835 38	
Settlements,	-		849,350 00	
Clinton sewerage system:—				
Engineering,	6,407 28		18,668 87	
Preliminary work,	81 78		1,852 76	
Contracts,	38,902 91		71,269 83	
Additional work,	6,647 33		7,976 04	
Real estate,	4,020 00		8,200 00	
		58,674 39		989,498 73
<i>Examination of Existing Water Works, and Payments on Account of Same.</i>				
Engineering,	\$2,252 51		\$14,078 31	
Legal, conveyancing and expert, .	781 00		5,647 92	
Settlements,	-		5,025,000 00	
		3,033 51		5,044,726 23
<i>Investigations for High-level Aqueduct.</i>				
Engineering,	\$7,142 07		\$7,142 07	
Preliminary work,	662 79		662 79	
		7,804 86		7,804 86
<i>Amounts carried forward, .</i>		\$2,127,918 70		\$17,845,025 90

EXPENDITURES FOR DIFFERENT WORKS.	For the Year ending December 31, 1899.	From Beginning of Work, and ending December 31, 1899.
<i>Amounts brought forward,</i>	<i>\$2,127,918 70</i>	<i>\$17,845,025 90</i>
<i>Pipes, Valves, Castings, etc., sent first to Storage Yards, and afterwards transferred as needed to Different Parts of the Work.</i>		
Sent to storage yards,	\$60,149 01	\$1,561,410 77
Transferred from storage yards to works and included in costs above,	85,747 87*	1,439,885 29
Balance from beginning of work,		121,525 48
Excess of transfers over purchases during the year 1899 (deducted),	25,598 86*	
	\$2,102,319 84	
<i>Maintenance and Operation.</i>		
Administration,	8,569 89	15,324 95
General supervision:—		
Services,	\$1,785 50	\$3,260 50
Supplies and expenses,	496 89	682 16
	2,282 39	3,942 66
Taxes,	7,964 68	11,518 66
Dam and aqueduct department:—		
General superintendence:—		
Services,	\$1,010 00	\$2,082 48
Supplies and expenses,	271 06	572 06
Dam and aqueduct:—		
Labor,	5,882 41	9,539 38
Supplies and expenses,	832 80	1,581 94
Sanitary inspection:—		
Labor,	268 26	502 03
Supplies and expenses,	43 10	76 12
Clinton sewerage system:—		
Pumping station:—		
Labor,	349 00	349 00
Fuel,	200 73	200 73
Repairs and supplies,	141 13	141 13
Sewers, screens and filter beds:—		
Labor,	268 51	268 51
Repairs and supplies,	18 22	18 22
	9,285 22	15,331 60
Sudbury department:—		
General superintendence:—		
Services,	\$3,541 45	\$10,220 31
Supplies and expenses,	893 22	2,429 79
<i>Amounts carried forward,</i>	<i>\$4,434 67 \$2,130,412 02</i>	<i>\$12,650 10 \$18,012,669 25</i>

* In order to show the full cost of each part of the work, there has been included the value of pipes, valves, etc., originally charged to stock and since transferred to the works. As the amount thus transferred during the year 1899 exceeded by \$25,598.86 the amount received for the same period, being material on hand from former years, this excess is deducted from the aggregate of costs, the result being the amount expended during the year for construction and acquirement.

EXPENDITURES FOR DIFFERENT WORKS.	For the Year ending December 31, 1899.		From Beginning of Work, and ending December 31, 1899.	
<i>Amounts brought forward, . . .</i>	\$4,434 67	\$2,130,412 02	\$12,650 10	\$18,012,669 25
<i>Maintenance and Operation — Con.</i>				
<i>Sudbury department — Con.</i>				
Superintendence, Framingham office:—				
Labor,	4,919 50		8,831 19	
Supplies and expenses, . . .	557 74		1,324 62	
Sudbury reservoir:—				
Labor,	4,956 00		7,773 44	
Supplies and expenses, . . .	2,272 18		2,859 84	
Ashland reservoir:—				
Labor,	1,202 50		2,266 71	
Supplies and expenses, . . .	339 65		545 20	
Hopkinton reservoir:—				
Labor,	1,499 75		3,632 18	
Supplies and expenses, . . .	323 17		925 57	
Whitehall reservoir:—				
Labor,	216 50		454 50	
Supplies and expenses, . . .	37 98		175 29	
Framingham reservoirs, 1, 2 and 3:—				
Labor,	3,436 84		6,496 75	
Supplies and expenses, . . .	905 06		1,985 84	
Lake Cochituate:—				
Labor,	2,424 54		4,451 86	
Supplies and expenses, . . .	425 49		819 65	
Pegan filters:—				
Labor,	2,487 36		4,447 33	
Supplies and expenses, . . .	851 57		1,683 85	
Sudbury and Cochituate water-sheds:—				
Labor,	33 00		447 00	
Supplies and expenses, . . .	205 73		437 40	
Sanitary inspection:—				
Labor,	2,231 74		4,483 04	
Supplies and expenses, . . .	249 38		430 93	
Sudbury and Cochituate aqueducts:—				
Labor,	11,173 77		19,907 18	
Supplies and expenses, . . .	7,080 41		10,358 95	
Chestnut Hill reservoir:—				
Labor,	9,420 78		16,776 26	
Supplies and expenses, . . .	2,117 12		2,983 97	
Biological laboratory:—				
Labor,	2,724 00		5,424 31	
Supplies and expenses, . . .	695 52		1,827 30	
		67,221 95		124,400 26
<i>Amounts carried forward, . . .</i>		\$2,197,633 97		\$18,137,069 51

EXPENDITURES FOR DIFFERENT WORKS.	For the Year ending December 31, 1899.	From Beginning of Work, and ending December 31, 1899.
<i>Amounts brought forward, . . .</i>	<i>\$2,197,633 97</i>	<i>\$18,137,069 51</i>
<i>Maintenance and Operation — Con.</i>		
Distribution department: —		
Superintendence: —		
Services,	\$4,843 49	\$6,576 60
Supplies and expenses, . . .	749 61	1,339 71
Chestnut Hill high-service pumping station, pumping service: —		
Labor,	23,882 72	46,588 63
Fuel,	17,222 45	33,339 15
Repairs,	1,645 19	3,707 30
Oil, waste and packing, . . .	812 72	1,531 55
Small supplies,	910 45	1,740 66
Melrose pumping station, pumping service: —		
Labor,	907 52	2,364 60
Fuel,	509 93	2,317 48
Repairs and supplies,	250 82	673 56
Malden pumping station, pumping service: —		
Labor,	4,930 74	4,930 74
Fuel,	6,136 04	6,136 04
Repairs and supplies,	994 60	994 60
Medford pumping station, pumping service: —		
Labor,	1,834 75	1,834 75
Fuel,	1,310 40	1,310 40
Repairs and supplies,	333 18	333 18
Chelsea pumping station, pumping service: —		
Labor,	3,347 45	4,114 45
Fuel,	2,503 23	3,586 23
Repairs and supplies,	1,086 92	2,099 93
Somerville pumping station, pumping service: —		
Labor,	2,648 91	2,648 91
Fuel,	2,621 08	2,621 08
Repairs and supplies,	432 39	432 39
West Roxbury pumping station, pumping service: —		
Labor,	2,609 34	2,609 34
Fuel,	1,217 71	1,217 71
Repairs and supplies,	80 28	80 28
Everett pumping station, pumping service: —		
Labor,	739 25	739 25
Fuel,	340 24	340 24
Repairs and supplies,	74 73	74 73
<i>Amounts carried forward, . .</i>	<i>\$84,976 14 \$2,197,633 97</i>	<i>\$136,283 49 \$18,137,069 51</i>

EXPENDITURES FOR DIFFERENT WORKS.	For the Year ending December 31, 1899.	From Beginning of Work, and ending December 31, 1899.
<i>Amounts brought forward, . . .</i>	\$84,976 14 \$2,197,633 97	\$136,283 49 \$18,137,069 51
<i>Maintenance and Operation—Con.</i>		
Distribution department— <i>Con.</i>		
Revere pumping station, pumping service:—		
Labor,	559 50	559 50
Fuel,	481 86	481 86
Repairs,	57 02	57 02
Buildings at Chestnut Hill reservoir:—		
Labor,	321 84	1,557 08
Supplies and expenses, . . .	33 23	299 23
Spot Pond:—		
Labor,	296 11	1,162 67
Supplies and expenses, . . .	129 10	497 42
Mystic Lake, conduit and pumping station:—		
Labor,	3,498 54	6,200 83
Supplies and expenses, . . .	1,470 54	2,526 83
Mystic reservoir, College Hill:—		
Labor,	1,820 79	3,480 66
Supplies and expenses, . . .	361 85	1,662 40
Fells reservoir:—		
Labor,	164 50	164 50
Supplies,	21 00	21 00
Arlington stand-pipe,	120 26	120 26
Low service, pipe lines:—		
Labor,	5 953 72	17,209 33
Supplies and expenses, . . .	2,048 65	7,761 01
Northern high service, pipe lines:—		
Labor,	1,141 50	1,578 50
Supplies and expenses, . . .	2,033 70	5,016 35
Southern high service, pipe lines:—		
Labor,	1,724 25	2,960 32
Supplies and expenses, . . .	335 70	932 85
Glenwood pipe yard:—		
Labor,	1,648 23	1,648 23
Supplies,	502 27	502 27
Stables:—		
Labor,	2,692 62	2,692 62
Vehicles, harnesses and fittings, .	351 13	351 13
Subsistence,	445 91	445 91
Miscellaneous supplies, . . .	618 74	618 74
	113,808 70	196,792 01
Total for constructing, acquiring and maintaining works, . . .	\$2,311,442 67	\$18,333,861 52

(b) Receipts.

The total amount of receipts from rents, sales of property, etc., for the year beginning January 1, 1899, and ending December 31, 1899, is \$40,153.39, and the total amount from the time of the organization of the Board, July 19, 1895, to December 31, 1899, is \$108,334.53. The general character of these receipts is as follows:—

	For the Year ending December 31, 1899.	From Beginning of Work, and ending December 31, 1899.
Forfeiture for contracts awarded, but not executed,	—	\$500 00
Rents from real estate,	\$10,994 08	27,850 07
Sales of real estate and buildings,	1,986 66	4,554 26
Land products,	2,648 06	6,930 39
Labor, tools and supplies,	3,727 06	7,534 33
Payments on account of admission into the Metropolitan Water District,	15,000 00	35,005 00
Payments on account of supplying water to towns outside of District,	645 84	20,645 84
Water furnished to water companies,	5,080 38	5,080 38
Unclassified receipts,	71 31	234 26
Totals,	\$40,153 39	\$108,334 53

The foregoing receipts have been credited to the various objects or works, as follows:—

	For the Year ending December 31, 1899.	From Beginning of Work, and ending December 31, 1899.
Admission into Metropolitan Water District (Nahant, Quincy and Arlington),	\$15,000 00	\$35,005 00
Supplying water to towns outside of water district (Swampscott),	645 84	20,645 84
Water furnished to water companies,	5,080 38	5,080 38
Construction:—		
Wachusett Reservoir,	14,398 76	30,716 33
Wachusett Aqueduct,	24 70	271 12
Sudbury Reservoir,	—	6,265 00
Distribution system,	2,600 63	6,290 99
Diversion of water, Clinton sewerage system,	202 26	271 76
Maintenance:—		
Wachusett Aqueduct,	415 87	649 87
Sudbury system,	1,063 55	2,323 67
Distribution system,	721 40	814 57
Totals,	\$40,153 39	\$108,334 53

(c) *Assets.*

The following is an abstract of the assets, the more important items being given : —

Office Furniture, Fixtures and Supplies.

Book cases,	31	Reference books,	419
Plan cases,	43	Stools,	151
Miscellaneous cases and cabinets,	57	Coal stoves,	58
Chairs,	344	Tables, office,	74
Desks,	121	Tables, draughting,	41
Letter-copying presses,	22	Telephones,	17
Numbering machines,	5	Typewriters,	17
Railroad tickets, value,	\$1,620	Stamped envelopes, value,	\$670

Engineering and Scientific Instruments and Supplies.

Biological laboratory outfit,	1	Planimeters,	21
Chemical laboratory outfit,	1	Levelling, measuring and sight rods,	182
Drawing boards,	112	Rubber boots, pair,	254
Calculating instruments,	6	Scales,	245
Cement-testing machines,	5	Section liners,	4
Current meters,	2	Straight-edges,	78
Electrical instruments,	3	Tapes,	209
Engineers' levels,	28	Transverse testing machines,	4
Pantographs,	3	Transits,	26
Photographic outfit,	1		

Police Supplies.

Belts,	23	Handcuffs, pair,	31
Cells,	6	Revolvers,	5
Clubs,	32	Twisters, pair,	29
Beds,	11	Stretchers,	3

Horses, Vehicles, Field Machinery, etc.

Horses,	19	Carts,	9
Carriages,	9	Sleds,	5

Horses, Vehicles, Field Machinery, etc. — Concluded.

Sleighs,	14	Blankets,	51
Wagons,	15	Harnesses,	33
Harrows,	3	Robes,	21
Mowing machines,	2	Bush hooks, bill hooks, scythes, etc.,	270
Ploughs,	10	Hand carts,	6
Horse rakes,	3	Border knives, hedge trimmers, etc.,	20
Road rollers,	4	Lawn mowers,	10
Road scrapers,	2		
Tedders,	2		

Machinery, Tools and Other Appliances and Supplies.

Adzes,	3	Grindstones,	27
Anchors,	19	Hoes, all kinds,	177
Anvils,	12	Forks,	144
Axes and hatchets,	166	Hammers,	399
Barrows,	43	Heater,	1
Bars, crow and others,	225	Hoisting buckets,	37
Blasting battery,	2	Hose, all sizes, feet,	5,130
Blocks, all kinds,	185	Ice tools,	131
Blower,	1	Indicators,	9
Boats, row,	18	Injectors and inspirators,	12
Boilers,	33	Jacks,	49
Diamond drills,	2	Ladders, feet,	950
Diamonds for same, K,	74	Lathes,	4
Chisels,	373	Lumber, M feet B. M.,	439
Carts and cars,	22	Mattocks,	193
Chain hoists,	27	Mauls,	22
Concrete mixer,	1	Meters, pressure, etc.,	10
Derricks,	14	Motors,	2
Dredges, scows, etc.,	12	Oil cabinets and tanks,	24
Drilling machines,	20	Pile drivers,	4
Dynamos,	4	Pipe cutters,	19
Engines,	23	Die plates, stocks, etc.,	32
Forges,	7	Pipe-tapping machine,	1
Furnaces, melting,	5	Picks,	422
Gauges,	58	Planer,	1

Machinery, Tools and Other Appliances and Supplies — Concluded.

Plumber's furnace,	1	Tongs,	118
Pumping engines,	5	Tool and coal boxes, etc.,	43
Pumps, steam,	46	Trench and other braces,	29
Pumps, centrifugal,	15	Trucks,	3
Pumps, diaphragm,	16	Vises,	34
Pumps, miscellaneous,	21	Winches,	1
Rakes,	175	Wrenches,	675
Rammers,	88	Wrought-iron pipe, all sizes,	
Rock drills,	2	feet,	13,400
Saws,	113	Cast-iron pipe, miscellaneous	
Scales, yard, platform, etc.,	29	lots, tons,	230
Settees, Chestnut Hill grounds,	47	Cast-iron pipes, special castings,	
Shovels, scoops, spades, etc.,	996	valves, man-hole frames and	
Shovel, steam,	1	covers, etc., at pipe yards, esti-	
Stone crusher,	1	mated value,	\$119,210.54
Temporary buildings and structures,	83		

Real estate connected with works not completed: —

Real estate in the site of the proposed Wachusett Reservoir and margins; out-lying property in Clinton, Boylston, West Boylston and Lancaster; Chestnut Hill low-service pumping station and surroundings; Spot Pond, with pumping station building and surrounding land in Stoneham, and lot for reservoir and stand-pipe on Forbes Hill, Quincy.

Completed works, including real estate connected therewith: —

Wachusett Aqueduct, Sudbury Aqueduct, Cochituate Aqueduct; Whitehall Reservoir, Hopkinton Reservoir, Ashland Reservoir, Framingham Reservoirs Nos. 1, 2 and 3, Sudbury Reservoir, Lake Cochituate, Chestnut Hill Reservoir, Fells Reservoir; Mystic Lake, Conduit and pumping station (not used); Mystic Reservoir; Arlington stand-pipe; Chestnut Hill high-service pumping station; temporary pumping station, Arlington; sewerage system and pumping station, Clinton; 67.33 miles of pipe line in distribution system; Mystic yard and buildings; Glenwood yard and buildings; Clinton office and grounds.

(d) Liabilities.

There are liabilities as follows : —

Unpaid bills,	—*
Due on monthly pay rolls,	\$7,400 00
Due on weekly pay rolls,	3,900 00
	<u>\$11,300 00†</u>

Reserved on Approved Monthly Estimates for Work done (not due until Completion of Contracts).

NAME.	Work.	Amount.
Moulton & O'Mahoney,	Wachusett Reservoir,	\$14,595 71
Cenedella Bros.,	Wachusett Reservoir,	7,513 94
Nawn & Brock,	Wachusett Reservoir,	7,268 00
Busch Bros.,	Wachusett Reservoir,	3,488 93
Busch Bros.,	Wachusett Dam,	2,426 02
Silvio Casparis,	Wachusett Aqueduct,	600 00
Silvio Casparis,	Wachusett Aqueduct,	700 00
Auguste Saucier,	Marlborough Brook filters,	6,268 62
Baker & Judson,	Gate chamber and connections, Chestnut Hill Reservoir,	2,440 16
Atlantic Works,	Chestnut Hill sluice gates,	891 15
Coffin Valve Company,	Chestnut Hill and Spot Pond (floor plates, etc.),	198 00
Norcross Bros.,	Chestnut Hill low-service pumping station,	34,844 91
McNeil Bros.,	High-service pumping station,	19,138 31
Brodhead Contracting Company,	Masonry core walls, Spot Pond,	4,598 37
Newell & Snowling Construction Company,	Improvement Spot Pond,	6,137 67
Moulton & O'Mahoney,	Improvement Spot Pond,	5,645 05
Newell & Snowling Construction Company,	Improvement Spot Pond,	1,884 83
Moulton & O'Mahoney,	Improvement Spot Pond,	3,300 77
P. H. Fitzgerald,	Improvement Spot Pond,	5,285 14
W. L. Clark & Co.,	Stable, Glenwood pipe yard,	3,625 00
		<u>\$130,850 58</u>

* Miscellaneous current bills of 1899, including those coming in from time to time after January 1, have since been paid.

† Since paid.

In addition to the above, there are amounts which will be due for two parcels of real estate in the Sudbury Reservoir, namely, heirs of John Nichols \$359, heirs of Horace Nichols \$90; for takings on the line of the Wachusett Aqueduct; and for takings, for damage to business, loss of employment and depreciation in real estate not taken, on account of the Wachusett Reservoir.

Amounts have been agreed upon in the following cases, but the deeds have not been passed: Harrison Neal, \$656; Guilford P. Heath, \$1,000; Ida J. Reid *et als.*, \$275.

On the claims of the following, it is impossible to state the amounts due for the land damages mentioned above, the same not having been liquidated, but being still subject to negotiation or adjudication: Margaret F. Tonnelly, heirs Thomas Prendergast, Margaret M. Cain, Bridget Padden, Patrick T. Moran, Harriet Wilder, James H. Woods, Lawrence Downey, Thomas Cain, heirs of Thomas H. O'Connor, Chas. A. Rand, trustee, David O'Connell, Thomas Connors, Charles E. Smith, G. C. Hudson, S. M. Church, R. P. Boynton, John N. Whittemore, Richard Bourne, Mary Williams Swinscoe, Maria A. Haskell, Harriet Griffin, Catherine McLean, Timothy John Fahy, Chloe Ann Ballou, William H. Buck, George E. Walker, Henrietta M. Johnson, Charles L. Johnson, Israel G. Howe, Charles B. Sawin, Eben S. and W. A. Fuller, W. O. Johnson, Joseph B. Moore, heirs Owen Kittredge, Bridget Kittredge, Felix Nugent, Joseph F. McDonald, Timothy J. and Mary A. Lynch, Clarence Carvill, James H. Moulton heirs, Martin F. O'Malley, Ashley Wood *et als.*, Levi L. Flagg, Fred E. Russell, Hattie E. Sawyer, Jeremiah Potter, J. R. Stott, Horace H. Lowe, Helen Spencer, Christian Schmidt, Sarah A. Laythe, G. A. Highway, Nathaniel L. Kendall *et als.*, Arthur W. Woods *et als.*, heirs of Herbert F. Newton, William R. Albertson, Charles F. Frazer *et al.*, Bigelow Carpet Company, Cornelius J. Mack *et als.*, Henry J. Barnes *et als.*, Arthur J. Bigelow, Hervey A. Gilmore *et als.*, Levi A. Bathrick heirs, Louis E. Denfield, Elijah Bemis, Charles E. Nichols, Nellie E. Burke, Catherine McGuinness, Edward Garrity *et al.*, George A. Dorrison, Joseph Dondero, John A. Frye, J. M. Sears, heirs of Owen Kelly, city of Boston, balance, city of Malden, balance, city of Medford, town of Melrose, town of Boylston, town of Southborough.

VI. WORK ACCOMPLISHED AND FOR THE FUTURE.

Since the organization of the Board, in the year 1895, by the work of its various departments, the Wachusett Aqueduct has been built; the Sudbury Reservoir has been completed; large additions have been made to the pumping facilities; upwards of 60 miles of main pipe have been laid in the various parts of the district; Spot

Pond and the works for the water supply of the city of Boston have been taken by the Board; the waters of the South Branch of the Nashua River have been diverted for the supply of the District; settlements have been effected by voluntary arrangements with the parties injured, for five-sixths, as is estimated, of the entire amount payable on account of the lands taken for the Wachusett Reservoir; and the work of supplying water to the various cities and towns of the District for the use of about 800,000 inhabitants has been carried on for two years. A sewerage system for the town of Clinton has been constructed, and considerable has been accomplished, by the building of filter-beds and the drainage of swamps, and by the suppression of smaller nuisances, for the prevention of pollution of the waters. Not only has a large amount of work preliminary to the construction of the great dam at Clinton been performed and considerable excavation been made for the foundation of the dam, but extensive beginnings have been made in the stripping of the soil from the surface of the land to be submerged in the Wachusett Reservoir, and in the building of the North Dike which is to flank the masonry dam on the north. Large pumping stations at Chestnut Hill Reservoir and Spot Pond, with their equipment of pumping engines, are approaching completion. The work of stripping, improving and enlarging Spot Pond is in process of accomplishment, and a high-service distributing reservoir in Middlesex Fells has been completed.

The carrying on of this work has involved the employment each year of engineers varying from 150 to 193 in number, and of skilled employes and laborers, under contracts and otherwise, numbering from 2,500 to 4,000; the making of 183 formal written contracts; and the expenditure for construction and land damages, exclusive of amounts paid to the city of Boston, of about \$12,000,000.

The quantity of water which the various sources of supply of the Metropolitan Water District are capable of furnishing in a very dry year has been increased since the year 1895 from 62,000,000 gallons per day to about 105,000,000 gallons per day.

By reason of the better water coming from the Nashua River, and of the works which have been constructed for the prevention of pollution and the benefits which have already come from larger storage, the water which has been supplied to the Metropolitan

District during the last year was superior to that which had hitherto been afforded.

It is believed by the Board and its engineers, that, through the larger works of supply constructed by the joint action of the municipalities and the saving effected by the maintenance of a single great system in place of many smaller systems, an ampler as well as purer supply of water will be afforded to the Metropolitan Water District at a cost to the cities and towns materially decreased and decreasing.

The building of the Wachusett Dam and Reservoir is the larger work of the future, and their construction will, it is probable, require a further term of five years. The period since the year 1895 has shown an unexpectedly rapid increase in the consumption of water for the whole Metropolitan Water District and Swampscott from 69,000,000 gallons per day in the year 1895 to 91,000,000 gallons per day in the year 1899, — an increase during the past year alone of 9.6 per cent., or 8,000,000 gallons per day. At the same time, the District has encountered an unprecedented season of light rainfall. The amount of water yielded by the sources of supply during the last eight months of the present year has been less, with the possible exception of that of the year 1880, than that of the corresponding eight months in any year of the last twenty-five years during which accurate measurements have been taken.

Had there been a considerable delay in providing the additional supply which has been diverted from the Nashua River, or had not a vigorous prosecution of the work been made, the cities and towns in the Metropolitan District would have been seriously affected during the past season by the scarcity of water. The rapid increase in consumption and the possibility of dry seasons in the future seem to demand that, in order to avoid further danger, an equally vigorous prosecution of the work should be continued until the capacity of the sources of supply is further increased from the present amount of 105,000,000 gallons per day to the 173,000,000 gallons per day which are promised by the completion of the Wachusett Reservoir.

In addition to the completion of the works begun and in progress, the State Board of Health contemplated, as a part of the scheme for furnishing the additional supply, the construction of another aqueduct, beginning at the Sudbury Dam in Southborough

and continuing to some point in the town of Weston, whence the water should be brought into the District by great main pipe lines. It was calculated that such an additional aqueduct would be required to make available the entire addition to the water supply, and would be so required within the period of ten years from the year 1895 ; but, inasmuch as its construction was not to be required for several years, the appropriation made by the Metropolitan Water Act was not assumed to cover its cost. The increase in consumption would seem to indicate that the beginning of the construction of this aqueduct, which will probably require three years for its completion, cannot safely be deferred beyond the current year.

The completion of the works in progress and the building of the new aqueduct with its connections will be a substantial carrying out of the scheme for direct relief imposed by the Act of the year 1895, in order "to provide a Metropolitan Water Supply."

Respectfully submitted,

HENRY H. SPRAGUE.
WILMOT R. EVANS.
HENRY P. WALCOTT.

Boston, January 1, 1900.

REPORT OF THE CHIEF ENGINEER.

To the Metropolitan Water Board.

GENTLEMEN :— The following is a report of the operations of the engineering department for the year ending December 31, 1899.

ORGANIZATION.

There have been few changes in the general organization of the engineering department. Reuben Shirreffs resigned as principal office assistant February 20, 1899, to accept a position elsewhere, and Alfred D. Flinn was promoted to fill the vacancy.

The list of engineers reporting directly to the chief engineer is as follows :—

DEXTER BRACKETT, .	. <i>Engineer, Distribution Department.</i>
DESMOND FITZGERALD, .	. <i>Engineer, Sudbury Department.</i>
THOMAS F. RICHARDSON, .	. <i>Engineer, Dam and Aqueduct Department.</i>
HIRAM A. MILLER, .	. <i>Engineer, Reservoir Department.</i>
ALFRED D. FLINN, .	. <i>Principal Office Assistant.</i>
JOHN N. FERGUSON, .	. <i>Office Assistant.</i>

Mr. FitzGerald was offered a position as chief engineer of the Special Commissioners of the Chicago Drainage Canal, and was given a leave of absence without pay to enable him to accept this position. He left June 6 and returned November 2. During his absence his principal assistants, Edward S. Larned, in charge of construction, Charles E. Haberstroh, assistant superintendent, located at South Framingham, and Charles W. Sherman, assistant engineer in the main office, reported directly to the chief engineer.

Joseph P. Davis, A. Fteley and Hiram F. Mills have continued to act as consulting engineers.

Will J. Sando has continued to fill the position of superintendent of pumping stations, and has also acted as the inspector of pumping and other machinery.

The amount of work constructed in 1899 was considerably larger than in 1898, owing mainly to the more active prosecution of the

work of constructing the Wachusett Reservoir and to the beginning of work upon the improvement of Spot Pond.

As a consequence of this increased amount of work it has been necessary to increase the engineering force from time to time in the lower grades. At the beginning of the year this force, including both those engaged upon the construction and maintenance of the works, numbered 141; during the year the force increased to a maximum of 196; and at the end of the year it numbered 183. In addition to the engineering force, which included the engineers engaged upon the inspection of the work, other inspectors have been employed to inspect pipe-making, pipe-laying, machinery and masonry. The maximum number so employed at any one time during the year was 15.

Gangs of men under the immediate direction of foremen and under the general direction of the engineers have been employed to drive sheet piling at the North Dike of the Wachusett Reservoir, upon the construction of a flume and other temporary work at the Wachusett Dam, to dig drainage ditches in swamps, to lay pipes in the Metropolitan Water District and to do other minor work. There has also been a maintenance force, averaging 117, employed at the pumping stations and in connection with the maintenance of reservoirs, aqueducts, pipe lines and other works.

FORCE EMPLOYED ON WORKS.

The largest force employed upon the works at any one time during the year was in the latter part of September, as follows :—

	Men.	Horses.
Contractors' force :—		
Reservoir department,	880	234
Dam and aqueduct department,	78	14
Sudbury department,	116	34
Distribution department,	1,259	307
	<hr/> 2,333	<hr/> 589
Day-labor force, construction,	330	23
Engineering force, including engineer inspectors and those engaged upon maintenance,	193	—
Inspectors not engineers,	15	—
Maintenance force, not including civil engineers,	120	5
	<hr/> 2,991	<hr/> 617

CONSTRUCTION.

CONTRACTS.

A detailed statement of the contracts made and pending during the year is given in Appendix No. 1. The following statement gives a summary of all the formal contracts from the beginning of the work to the end of 1899 : —

PORTION OF WORK.	Number of Contracts.	Approximate Amount.
Wachusett Reservoir,	17	\$1,770,859 85
Wachusett Aqueduct and Clinton sewerage,	20	1,516,259 67
Wachusett Dam (preliminary work),	1	19,120 00
Sudbury Reservoir, contracts assumed from the city of Boston (uncompleted portions),	11	583,220 54
Sudbury department, reservoir, filter-beds and pipe lines, contracts made by Metropolitan Water Board,	20	895,850 72
Distribution department, including pipes purchased for other departments,	124	3,405,755 42
Totals,	193	\$8,191,066 20

Number of contracts made and assumed in 1896,	56
Number of contracts made in 1897,	53
Number of contracts made in 1898,	40
Number of contracts made in 1899,	44

193

Amount of contracts made and assumed in 1896, including only the uncompleted portions of contracts assumed from the city of

Boston,	\$3,893,934 31
Amount of contracts made in 1897 (approximate),	1,232,114 52
Amount of contracts made in 1898 (approximate),	725,159 55
Amount of contracts made in 1899 (approximate),	2,339,857 82
	\$8,191,066 20

Number of contracts completed in 1896,	13
Number of contracts completed in 1897,	57
Number of contracts completed in 1898,	57
Number of contracts completed in 1899,	34
Number of contracts uncompleted December 31, 1899,	32

193

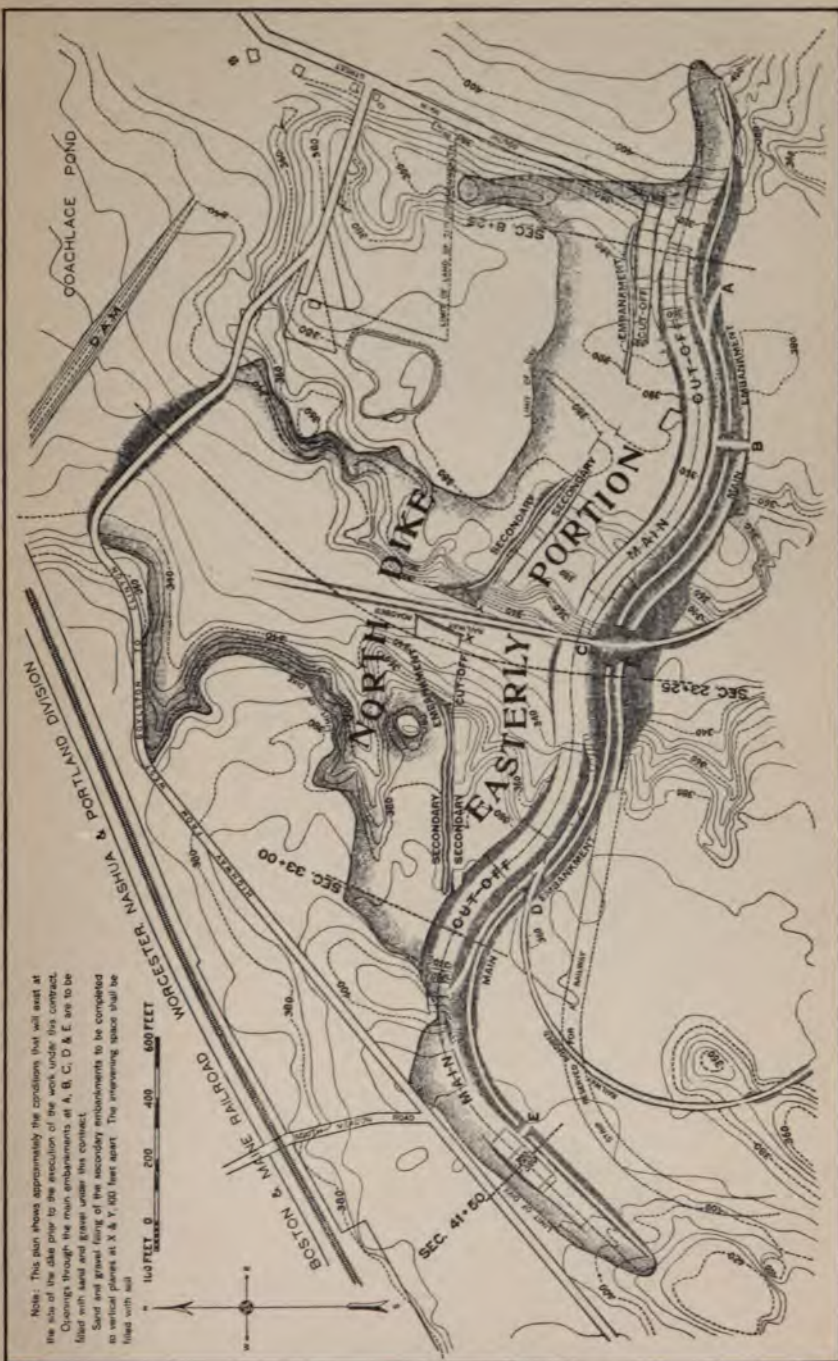
Amount of contracts completed in 1896,	\$651,449 77
Amount of contracts completed in 1897,	3,013,206 37
Amount of contracts completed in 1898,	1,435,228 08
Amount of contracts completed in 1899,	983,218 37
	<hr/>
	\$6,083,102 59
Amount of contracts uncompleted December 31, 1899 (approximate),	2,619,963 61
	<hr/>
	\$3,703,066 20
Deduct for work done on 11 Sudbury Reservoir contracts by city of Boston,	512,000 00
	<hr/>
	\$3,191,066 20
Value of work done by contract to December 31, 1896,	\$2,061,910 38
Value of work done by contract from January 1, 1897, to December 31, 1897,	2,647,063 53
Value of work done by contract from January 1, 1898, to December 31, 1898,	703,141 71
Value of work done by contract from January 1, 1899, to December 31, 1899,	1,206,791 72
	<hr/>
	\$6,618,907 34
Value of work remaining to be done on uncompleted contracts December 31, 1899,	1,572,158 86
	<hr/>
	\$8,191,066 20

In the case of all contracts completed up to the present time final settlements have been made without any legal controversy.

RESERVOIR DEPARTMENT.

HIRAM A. MILLER, *Department Engineer.*

On account of the large increase in construction work in this department, the organization of the engineering staff has been materially changed and the force largely increased. At the beginning of the year Alexander E. Kastl, in charge of the work at the North Dike, including both contract and day-labor work, was the only division engineer, and the assistant engineers were Charles A. Bowman, Ernest H. Baldwin, David Hinckley, Moses J. Look and Harry J. Morrison. On April 21 Charles E. Wells, who had previously been in charge of the construction of a division of the Wachusett Aqueduct, was transferred to the reservoir department and placed in charge of the inspection of the removal of soil, with the rank of division engineer. On May 21 Charles A. Bowman, assistant engineer, was promoted to the rank of division engineer and placed in charge



PLAN OF EASTERLY PORTION OF NORTH DIKE SHOWING LOCATIONS OF EMBANKMENTS AND CUT-OFF TRENCHES AND RAILWAY
USED FOR CONSTRUCTION, COPIED FROM DRAWING FOR CONTRACT NO. 166.

of the measurements, estimates and engineering work connected with the removal of soil other than the inspection. Mr. Bowman has also had charge of the road construction during the year. On May 21 Wilfred A. Clapp, who had previously been a transitman, was assigned to the vacancy caused by the promotion of Mr. Bowman; and on July 10 Arthur W. Tidd was promoted to the rank of assistant engineer, to fill a vacancy caused by the resignation of David Hinckley.

The total engineering force in this department has varied from 32 to 69. In addition to this force a portion of the drafting force of the dam and aqueduct department has been employed upon the work of the reservoir department, increasing the total force employed by an average of 2.

The main office of this department has been continued in the building erected by the Board in Clinton. The two branch offices used by construction parties in the same town, one on Boylston Street and the other near the North Dike, have been continued. An additional office has been established at Sawyer's Mills in the town of Boylston. The branch office at West Boylston has been continued throughout the year.

A telephone line has been constructed from the main dam in Clinton to the branch office in West Boylston.

NORTH DIKE.

Cross-sections have been completed of the entire site of the dike, and a revised estimate of the quantities of soil needed for that portion of the dike where soil is required has been made. The rate of filtration through 171 samples of material has been determined.

Joseph D. Gennaro continued work on his contract for excavating about 290,000 cubic yards of earth at the easterly portion of the dike until June 14, when, on account of financial difficulties, he was unable to continue the work; and an agreement for completing the excavation embraced under his contract was made with Moulton & O'Mahoney, who had the contract for partially refilling the excavations with soil. From January 1 to June 14 Mr. Gennaro moved approximately 85,000 cubic yards, making a total from the beginning of his work of 219,413 cubic yards. The maximum force employed by him in 1899 was 145 men and 58 horses.

On April 10 a contract was made with Moulton & O'Mahoney for the removal of soil from that portion of the reservoir near the east-

erly portion of the dike and for depositing and rolling it in 6-inch layers in the large excavations being made by Joseph D. Gennaro, and also in smaller excavations which their contract required them to make from 100 to 400 feet further north. The material from these latter excavations was used to construct earth embankments along the northerly side of the excavations, and also a road embankment near South Main Street. Work on this contract was commenced on April 13. Their maximum force has been 440 men and 146 horses. As previously stated, their work under this contract was subsequently increased by the uncompleted portion of the earth excavation under Joseph D. Gennaro's contract. They have completed the small excavations, the embankments north of them, the unfinished work on the Gennaro contract and the road embankment. The amount of excavation at the North Dike has been 113,900 cubic yards of earth and 3,813 cubic yards of soil. In addition to the excavations at the North Dike, Moulton & O'Mahoney have, under this contract, removed a large amount of soil from the reservoir to the dike, which will be referred to subsequently.

On June 13 a contract was made with Nawn & Brock for completing the easterly portion of the North Dike, with the exception of the slope paving, the greater portion of the dike to be made with soil removed from the site of the Wachusett Reservoir. The amount of the contract upon the basis of award is \$1,096,300. A plan and sections of this portion of the dike, reproduced from contract plans, are given opposite pages 78 and 80. The contract provides that selected soil shall be deposited in the excavations at the North Dike and on specified areas over and near the excavations, and shall be rolled in 6-inch layers until the embankments are raised to a height above the probable line of saturation when the reservoir is full. Between the embankments rolled in 6-inch layers and in other portions of the dike within 300 feet of the northerly side of the main embankments and below the maximum line of saturation, selected soil is to be deposited in 7½-foot layers. Work under this contract was commenced on July 20. Their work on the soil filling during the year has consisted of depositing one layer, averaging some 7 feet in depth, in Coachlace Pond, and depositing a small amount of soil in 6-inch layers in the large excavation east of Coachlace Pond. Their maximum force has been 432 men and 69 horses.

On June 1 a contract was made with Cenedella Brothers to excavate a trench, estimated to contain 155,000 cubic yards of earth and

CROSS SECTIONS OF DIKE

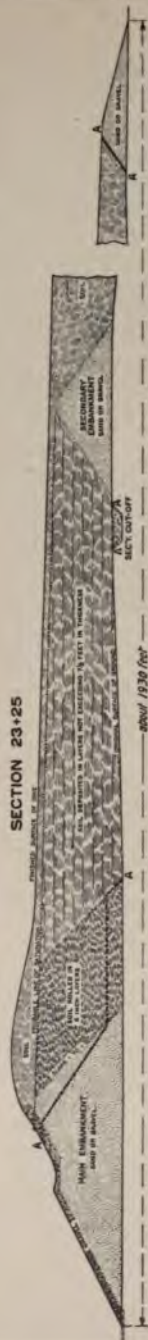
SECTION 41+50



SECTION 33+00



SECTION 23+25



SECTION 8+26



LONGITUDINAL SECTION OF DIKE ON LINE OF MAIN CUT-OFF

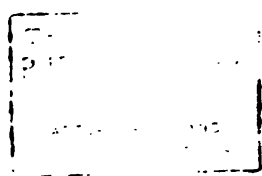


Note: A---A shows approximately the extent of the work on the site that will be completed under other contracts prior to the execution of the work under this contract.

0 10 20 30 40 50 60 80 FEET
SCALE

0 10 20 30 40 50 60 80 FEET
VERTICAL SCALE

SECTIONS OF EASTERLY PORTION OF NORTH DIKE SHOWING ORIGINAL SURFACE OF GROUND AND ARRANGEMENT OF MATERIALS IN CUT-OFF TRENCHES AND EMBANKMENTS, COPIED FROM DRAWING FOR CONTRACT NO. 166.



soil, through the coarser material at the westerly portion of the dike, to refill the same with soil from the site of the Wachusett Reservoir and to construct a drain at the northerly toe of the dike. This drain is necessary, as the dike is constructed south of the summit of a very low ridge, and the water falling between the summit of the ridge and the top of the dike would otherwise collect between them.

The contract with Cenedella Brothers included also the construction of a part of a road and the removal of soil from a portion of the site of the Wachusett Reservoir, both of which will be mentioned more particularly in other portions of this report.

Nearly all of the material removed from the trench was used in the construction of an earth embankment along the reservoir slope of the dike and in the road embankments. There is, however, surplus material which is being used to form an embankment at the northerly toe of the dike. Such soil as is suitable for the purpose is deposited in the trench and rolled in 6-inch layers; the rest is deposited near the northerly toe of the dike. Work was commenced on June 6. The maximum force was 211 men and 73 horses. They have excavated at the dike some 7,900 cubic yards of soil and 133,800 cubic yards of earth, have laid in the surface drain a little over 7,000 feet of sewer pipe of various sizes, from 4 to 15 inches in diameter, and have constructed 16 cubic yards of masonry, 30 cubic yards of paving and 18 manholes.

On December 12 a contract was made with Long & Little for excavating 650,000 cubic yards of soil within the site of the Wachusett Reservoir and depositing it in the westerly portion of the North Dike. This quantity of soil will construct approximately one-third of what remains of the westerly portion of the dike, not including the slope paving. At the end of the year they had just begun some preliminary work.

In addition to the contract work a large amount of work has been done at the North Dike by a day-labor force under the immediate direction of the engineers of the Board, as follows:—

As soon as the work of excavating the large trench which extends longitudinally under the highest part of the dike was sufficiently advanced, sheeting piles were driven in the bottom of the trench at places where the borings indicated that the underlying material might be somewhat pervious. This precaution was taken to prevent loss of water by percolation under the dike. Where the length of the piles was over 30 feet they were constructed of 2-inch spruce plank

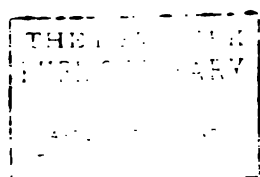
nailed together in three thicknesses ; where the length was less than 30 feet, 4-inch grooved spruce sheeting with hard pine splines was used. For driving the long sheeting piles a pile driver 50 feet high under the hammer was used. A large pump was installed in the bottom of the trench, and water was forced to the bottom of the sheeting piles through a 6-inch pipe and a 3½-inch or 2½-inch hose. By this method a powerful jet of water was made to act on the material at the bottom of the pile and the pile was easily forced down, the hammer being merely used to overcome the friction of the pile against the wedges and the pile previously driven. For driving the waling piles and the shorter sheeting piles smaller drivers were used. In connection with these drivers a water jet through a 1-inch hose and a 1-inch pipe was generally used, but some of the time the same method was used as with the large driver. The large driver commenced work east of Coachlace Pond June 1, and completed that portion September 23. It was started again west of Coachlace Pond November 15, and continued on this work to the end of the year. The piles driven by this driver have varied in length from 45 to 67 feet. The greatest number driven in one day was 24, having an average width of 16½ inches and an average length of 46 feet. One of the small drivers commenced driving 4-inch sheeting on the westerly portion of the dike September 12. On the easterly portion of the dike 6-inch sheeting has been driven for 1,556 linear feet and 4-inch for 360 linear feet, total 1,916 feet, and only 155 linear feet of 6-inch sheeting remain to be driven ; on the westerly portion 6-inch sheeting has been driven for 569 linear feet and 4-inch for 1,313 linear feet ; total, 1,882 linear feet ; total for both portions, 3,798 linear feet. At one time four pile drivers were engaged upon this work. Views of the large cut-off trench when the pile driving was in progress are given in this report.

Where the trench was excavated to the rock the surface of the rock was carefully washed off with a hose, using water under a considerable pressure ; all seams were carefully cleaned out, and, if small, filled with Portland cement mortar, or, if large, with brick laid in the mortar. Brick cut-off walls were built where needed, and the entire rock surface covered with two coats of grout put on with whitewash brushes ; 50,500 square feet of rock surface were treated in this way on the easterly portion and 13,200 feet on the westerly portion.

The removal of stumps, roots and logs from the bottom of Coachlace Pond, begun in 1898, was completed on January 18, 1899.



WACHUSETT RESERVOIR—PORTION OF NORTH DIKE, SHOWING MAIN
CUT-OFF TRENCH AND SHEET PILING.



Water has been pumped the entire year from that part of Coach-lace Pond included within the easterly portion of the North Dike. Since December 1, however, this work has been done at the expense of the contractor who has the main contract for the construction of this portion of the dike.

The maximum day-labor force employed at the North Dike has been 89 men and 13 horses.

RELOCATION AND CONSTRUCTION OF ROADS.

During the year satisfactory progress has been made upon the construction of roads around the reservoir to take the place of those discontinued and to be discontinued on account of the construction of the reservoir. On both the south and north sides of the reservoir the location of the new highways has been determined for the whole distance from Clinton to West Boylston, and they are either completed or under construction with the exception of a portion of the northerly road in Clinton, which cannot be completed until further progress has been made in the construction of the North Dike. A temporary highway, however, has already been built to accommodate travel at this place. Some progress has been made upon plans for the relocation of the roads in West Boylston.

Boylston Street.

Boylston Street, so called, in Clinton and Boylston, the new road leading from Clinton toward Boylston Centre, 15,725 feet in length, has been surfaced with broken stone. This work was divided into two sections: Section 1 commencing at the southwesterly end of the road in Boylston and extending to the overgrade crossing of the Central Massachusetts Railroad; Section 2 commencing at the Berlin Road, near the overgrade crossing of the railroad, and extending to a point near the bridge across the river at the Lancaster Mills in Clinton.

Section 1 was let to the Newell & Snowling Construction Company on April 7. Work on this section was commenced May 2 and completed on August 2. The maximum force employed, not including the work at the quarries, was 32 men and 36 horses; 5,882 tons of trap rock from Salem and Deerfield were used. The total cost of the work was \$11,869.83.

Section 2 was let to Asa Goddard on April 6. Work on this section was commenced May 2 and completed on August 16. The

maximum force employed, including the work at the quarry, was 52 men and 40 horses; 5,775 tons of Sterling trap rock were used on this section. The total cost of the work was \$11,368.95.

A day-labor force completed the guard fence, paved 3,650 feet of gutters, laid 835 feet of 5-inch side drains, constructed 3 catch-basins, dressed and seeded the slopes and kept the grass cut.

This road was completed and the construction approved by the county commissioners of Worcester County on December 14.

New Road from West Boylston to Boylston.

In accordance with the order and decree of the Massachusetts Highway Commission, dated May 6, 1899, the new highway between West Boylston and Boylston is to run from the junction of Temple Street and the State highway in West Boylston to the Shrewsbury Road in Boylston, a distance of 15,050 feet.

On July 29 a contract for constructing this road was made with Busch Brothers. Work under this contract was commenced August 10. At the end of the year the work was still in progress, and about two-thirds of the whole work had been completed. The maximum force employed at any time has been 241 men and 79 horses. The quantities of work done at the end of the year are approximately as follows: —

Earth excavation,	.	.	.	.	.	.	89,840 cubic yards.
Rock excavation,	.	.	.	.	.	.	1,892 " "
Slope paving,	.	.	.	.	.	.	490 " "
Masonry,	.	.	.	.	.	.	532 " "
Sewer pipe and cast-iron pipe culverts,	.	.	.	.	.	.	273 linear feet.

Of the earth excavation, 38,966 cubic yards represent soil stripped from the reservoir.

Some work has been done by a day-labor force dressing and seeding the slopes and erecting 1,500 feet of guard fences. These guard fences consist of two spruce rails fastened to chestnut posts.

New Road from Clinton to Lancaster Street, West Boylston.

This road has been built by several contractors and in part by day labor. A section near Clinton, consisting of an embankment which contains approximately 13,700 cubic yards of earth and gravel and 2,600 cubic yards of soil, was constructed by Moulton & O'Mahoney

in connection with their work at the North Dike. A day-labor force did the additional grading necessary to connect this embankment with South Main Street in Clinton, and constructed 1,050 feet of guard fence on the embankment, thus completing the road from the Clinton end to the temporary highway. From the westerly end of the temporary highway at the South Meadow Road the permanent highway extends 13,607 feet to Lancaster Street in West Boylston. This highway for the whole distance is nearly ready for public use. The first 900 feet west of the South Meadow Road were constructed by the day-labor force and completed January 19; the next 5,450 feet were constructed by Cenedella Brothers in connection with their contract for work at the North Dike, and required 10,401 cubic yards of earth and soil excavation at the site of the road. In addition to the above quantity, some 19,800 cubic yards of earth and soil were excavated from the trench at the North Dike and from the site of the reservoir, and used for completing the road embankments and for dressing slopes. The next 7,257 feet of road, extending to Lancaster Street in West Boylston, were constructed by Peter J. O'Malley, under a contract dated June 2. Work under this contract was commenced June 8 and completed October 3. The maximum force employed at any time was 126 men and 29 horses. The amount of the contract was \$20,166.28. The items of work were:—

Earth excavation,	42,038 cubic yards.
Rock excavation,	2,128 " "
Slope paving,	1,964 " "
Masonry,	170 " "
Sewer pipe culverts and side drains,	1,457 linear feet.

The above quantity of earth excavation includes 6,402 cubic yards of gravel borrowed for surfacing the road-bed, and 18,324 cubic yards of soil removed from the site of the Wachusett Reservoir.

Improvement of Lancaster Street, West Boylston.

Lancaster Street has been improved by reducing the grades, widening the travelled way and rebuilding the culverts and guard fences for a distance of 8,508 feet to Beaman Street in West Boylston. This work was done by Thomas H. Gill, under a contract dated June 3. Work was commenced June 12 and completed September 11. The maximum force employed was 68 men and 57

horses. The amount of the contract was \$8,438.87. The items of work were : —

Earth excavation,	17,342 cubic yards.
Rock excavation,	564 " "
Masonry,	57 " "
Paving,	38 " "
Sewer and cast-iron pipe culverts and drains, . . .	1,350 linear feet.

The earth excavation, as given above, includes 6,213 cubic yards of gravel borrowed for surfacing the road-bed.

In addition to the work of the day-labor force already enumerated, it has built guard fences on the new highway west of the South Meadow Road and on Lancaster Street for a total length of 8,650 feet, and has seeded the slopes with grass seed. The guard fences on these highways consist of a chestnut or oak rail fastened to the top of stone posts. The maximum day-labor force employed in connection with the roads has been 57 men and 15 horses.

In connection with the relocation of roads topographical surveys covering 88 acres have been made, 2 miles of trial lines have been run, 1.17 miles of located roads have been staked out, the quantities of material required for constructing $5\frac{1}{2}$ miles of road have been estimated and 115 stone monuments have been set on road locations.

BUILDING ROAD-BED FOR CONSTRUCTION RAILWAY.

During the year 1898 a railway road-bed was completed from a short distance south of Sandy Pond to the easterly portion of the North Dike, except for a short distance just north of Sandy Pond. This unfinished portion has since been completed by two contractors in connection with their work at the North Dike. During the first half of the year this road-bed was extended southerly and carried across the Nashua River and under the Central Massachusetts Railroad to a point near the South Clinton station.

The extension of the road-bed to the river was made by Moulton & O'Mahoney, under a contract dated April 6. Work under this contract was commenced April 10, and completed May 17. The maximum force employed was 66 men and 25 horses. The amount of the contract was \$2,894.83. The items of work were : —

Earth excavation,	19,621 cubic yards.
Rock excavation,	68 " "

The bridge 150 feet long across the river, the embankment at the south approach and the excavation 200 feet in length under the Central Massachusetts Railroad were constructed by day labor. A portion of the work on the Central Massachusetts Railroad bridge was performed by the Boston & Maine bridge force. Piles for the river bridge were delivered January 29, and the work was completed early in May.

At various times while the day-labor forces were employed on the road-bed the dam at Sawyer's Mills was torn down, as the stage of the water would permit, and the pond above the dam was drained.

REMOVAL OF SOIL.

Contracts for the removal of a large part of the soil on the site of the Wachusett Reservoir have been made during the year. The engineering and other work preliminary to this removal have been continued, and the necessary work of arranging the contracts, drawing up the specifications and making the preliminary estimates has been performed, in addition to the engineering and inspection required to supervise the contract work. The organic matter in 644 samples of soil has been determined.

In other portions of this report mention has been made of various contracts requiring the removal of soil from the reservoir to be used in connection with road construction and for filling at the North Dike ; so far as the work under these contracts embraced the removal of soil, it is more fully described below.

The contract with Moulton & O'Mahoney involved the removal of soil from Section 4. This section contains some 270 acres, and the preliminary estimate of work to be done called for the removal of 270,000 cubic yards of soil and the clearing and grubbing of 240 acres. At the end of the year the contractors had cleared and grubbed 125 acres and had removed 196,300 cubic yards of soil from 164 acres. Dump carts have been used exclusively for the transportation of the soil.

The contract with Cenedella Brothers included approximately 86 acres of clearing and grubbing and the removal of 210,000 cubic yards of soil from 130 acres of Section 5. Dump carts have been used exclusively for the transportation of soil. During the year 24 acres have been cleared and grubbed and 72,700 cubic yards of soil removed from 64 acres.

The contract with Nawn & Brock by the preliminary estimates required the removal of 3,250,000 cubic yards of soil from 1,700 acres, one-half of which required clearing and grubbing. This portion of the site of the reservoir is known as Section 6.

On August 30 the contractors, with the consent of the Board, sublet to Moulton & O'Mahoney that portion of the section north and east of the South Clinton station on the Central Massachusetts Railroad.

The plant placed upon the work by the principal contractors consists of 6 3-foot gage locomotives of 8 to 16 tons weight, and 493 dump cars, and they had at the end of the year about 5 miles of track in use. Where the ground is sufficiently level to admit of moving the tracks, the soil is shovelled directly into cars; in other places the soil is first loaded into carts and hauled to dumping platforms, where it is dumped into cars. Three of these platforms have been constructed and the fourth nearly so. The cars when loaded are hauled to the foot of the grade south of Sandy Pond by the lighter locomotives, and from there are taken to the dike by the larger locomotives.

The plant placed upon the work by the subcontractors consists of 3 8 to 10 ton, 3-foot gage locomotives, 2 hoisting engines and some 50 dump cars, and they have in use some 2 miles of track. So far they have loaded the soil directly into cars, but have commenced the construction of a dumping platform. They use a hoisting engine to haul cars up an incline from the low land near the river; from which soil is being removed, to the level land at the top of the slope, a locomotive bringing the cars to the foot of the incline and another hauling them from the head of the incline to the dike. Another hoisting engine at the dike lowers the cars into the deep excavation, where they are unloaded.

At the close of the year the total amount of work done upon this section consisted of 45 acres cleared and grubbed and 168,800 cubic yards of soil removed from 120 acres.

The contract with Long & Little requires the removal of 650,000 cubic yards of soil from 313 acres of the reservoir site known as Section 7. Of this area some 165 acres will have to be cleared and grubbed. At the end of the year they had not commenced the removal of soil.

All the soil removed under the above contracts is to be used in constructing the North Dike.

In connection with the construction of the new roads, Peter J. O'Malley removed 18,324 cubic yards of soil from 11½ acres and Busch Brothers 38,966 cubic yards from 26 acres.

There was removed from the reservoir site during the year, as enumerated above, 495,090 cubic yards of soil, and the area from which it was removed was 385½ acres; this, added to 105,287 cubic yards removed from 72½ acres in previous years, makes a total at the end of 1899 of 600,377 cubic yards removed from 458 acres.

LAND SURVEYS.

One hundred and thirty-eight acres have been surveyed and land plans have been revised. Taking plans for 1,051 acres of land at the Wachusett Reservoir site have been prepared during the year, making to the end of 1899 a total of 6,426 acres. Twenty-four stone monuments have been set to mark the margin of lands purchased or taken by the Board.

REAL ESTATE, CARE AND DISPOSAL.

Rents have been collected on houses in the possession of the Board; 18,062 linear feet of farm fences have been constructed; one house and several barns in Clinton have been moved and one house in Boylston has been moved. The pavilion at Cunningham's Grove has been torn down and the material used at the North Dike. The mill building and brick tenements at Sawyer's Mills have been torn down and the bricks removed by the Lancaster Mills Corporation. Twenty-six houses in West Boylston have been torn down or sold to be removed.

SANITARY INSPECTION.

The site of the Wachusett Reservoir has been carefully cared for by the sanitary and medical inspectors. One case of typhoid fever was removed from a house near the Cunningham Brook and taken to the Clinton Hospital. Other suspicious cases in contractors' camps have been removed at the medical inspector's request. The contractors have been required to keep their camps in a neat and sanitary condition. Where possible, sink drainage has been prevented from entering the site of the reservoir.

REMOVAL OF BODIES FROM ST. JOHN'S CATHOLIC CEMETERY.

Under an agreement made July 1, 1898, between the Roman Catholic Bishop of Springfield, the St. John's Catholic Cemetery

Association and the Metropolitan Water Board, the Association was to remove the bodies from the Catholic Cemetery in Clinton. A site for the new cemetery was selected in Lancaster.

During the present year, until May 13, a day force in the employ of the Association was engaged in preparing the new cemetery for the reception of the bodies, and arrangements were nearly perfected for removing the bodies, when, on account of unforeseen difficulties, the entire work was suspended.

On August 18, a small force, and on September 5 a larger force, was employed by the direction of the Board to continue the work commenced by the Association. The maximum force employed was 41 men and 10 horses.

A further agreement having been made for the carrying on of the work by a committee, the force employed by the Board ceased to do further work on December 9. The actual removal of the bodies from the old cemetery commenced on December 19, and about 157 bodies had been moved at the close of the year.

ENGINEERING.

One hundred and thirty intermediate benches have been set between the precise bench marks. Plans and schedules of real estate acquired by the Commonwealth have been made for the assessors of Clinton, Boylston and West Boylston. Gages established at the storage reservoirs on the watershed above the site of the main dam have been read from time to time, in order to determine the amount of water stored in or released from these reservoirs. A survey and plan of Counterpane Brook in Clinton have been made, as well as surveys and contour plans of the storage ponds in Clinton and Lancaster that discharge into it. These surveys covered 238 acres.

Some work has been done computing the capacity of the Wachusett Reservoir from the final levels taken in connection with the measurement of the soil removed.

Additional surveys and plans have been made for the use of the Attorney-General's office in real estate suits.

Information in regard to deeds, plans and descriptions of real estate has been furnished to the conveyancing department.

DAM AND AQUEDUCT DEPARTMENT.

THOMAS F. RICHARDSON, *Department Engineer.*

The work of construction in this department has related mainly to the completion of works for the interception, pumping and disposal of the sewage of Clinton ; to additional, temporary and preliminary works at the site of the Wachusett Dam ; and to the construction of ditches for the drainage of swamps upon the portion of the Sudbury watershed tributary to the open channel of the Wachusett Aqueduct and upon the Wachusett watershed.

There have been several changes in the organization of the engineering force during the year. Horace Ropes, division engineer, who has been in charge of various investigations relating to future work, resigned November 30, and the work under his direction has been placed in charge of his principal assistant, George W. Booth, who has been made assistant engineer. Charles E. Wells, who was in charge of the swamp improvement in the vicinity of the open channel of the aqueduct, was transferred to more important work in the reservoir department on April 21, and the swamp improvement was placed in charge of his principal assistant, Marshall Nevers, who has been made assistant engineer. Ernest G. Hopson has continued as head draftsman at the Clinton office. Chester W. Smith has had charge of the work at the Wachusett Dam and of miscellaneous surveys. Dan B. Clark was promoted to the position of assistant engineer on March 10, and was placed in charge of the completion of works for the interception and disposal of the sewage of Clinton. John L. Hildreth, Jr., has been in charge of river and aqueduct gagings during the year.

The engineering force at the beginning and end of the year was 27, and has varied during the year from 26 to 32.

The main office of the department has been at Clinton. A branch office was maintained at Northborough until December 26, when the force at this place was transferred to an office at West Boylston. A branch office was also established at Weston on December 26.

WACHUSETT DAM.

Various investigations and studies have been made relating both to the temporary and preliminary work at the dam and to the construction of the dam. Twenty-six additional borings, having an aggregate depth of 551 feet, have been made, mostly at the site of

the lower temporary dam, which is to be built to protect the excavation for the main dam from back water in the river. This makes the total number of wash-drill borings made to date at the site of the dam 875, having an aggregate depth of 16,905 feet.

Temporary and Preliminary Work at the Site of the Dam.

The upper protective dam and the upper portion of a flume, 40 feet in width, for carrying the water of the river past the large excavation to be made for the main dam were completed early in 1898.

As the completion of the temporary works would necessarily take considerable time, and the work could not well be carried on except in the drier portion of the year, it was thought advisable to complete them in 1899 so that it would be feasible to begin the operations upon the deep excavation for the main dam in the spring of 1900.

Where the flume crosses the site of the main dam it was thought advisable to complete the excavation for the dam and to build the comparatively small quantity of masonry to be built below the bottom of the flume before building the flume. A contract was therefore made on June 19 with Busch Brothers for making a temporary channel to divert the water of the river away from the site of the flume where it crosses the dam, making the excavations necessary in order to obtain a suitable foundation for the dam and building the masonry above referred to. As the excavation for the dam progressed it was found that the granite was more seamy than was anticipated. In the autumn it was decided that so much additional rock excavation would be necessary that it would be unwise to attempt to build the masonry, since it would not only require building in cold weather, but might also make it impracticable to complete the flume in time for freshets which might be expected in the early part of the year. The flume was therefore built across the excavation on timber supports.

On October 19 the contract with Busch Brothers was so modified as to provide that no masonry should be built, that they should be paid for further excavation of the rock as extra work, and should also be paid for all expenses incurred in preparing to build the masonry. At the site of the dam the contractors removed 13,200 cubic yards of earth and 4,980 cubic yards of rock at contract prices, and about 1,394 cubic yards of rock for which they were paid as extra work. They also opened a quarry upon land belong-

ing to the Commonwealth, about $1\frac{1}{2}$ miles from the site of the dam. Work was begun on June 27 and finished on December 14. The maximum force employed was 93 men and 18 horses.

A day-labor force was employed to extend the flume and construct other protective work. The flume is 40 feet in width for its whole length, is 16 feet high at the upper end and 13 feet high at the lower end. Its total length is about 700 feet, of which 200 feet were completed in 1898, as already mentioned. It is located on the westerly side of the river, where the ledge is close to the surface of the ground, and a part of the way above the level of the bottom of the flume. In order that the flume should not be undermined when the large excavation is made for the main dam, a part of it on each side of the dam is supported upon piles which were driven after the earth had been excavated to a depth of about 12 feet below the bottom of the flume. For this purpose 86 piles were driven above and 108 below the site of the dam. The timber supports where the flume crosses the site of the dam consist of posts, some of which are as much as 30 feet long, thoroughly braced and fastened down to the rock to prevent floating. The flume was nearly completed at the end of the year. The force employed in constructing the flume has varied from 17 to 35 men.

WACHUSETT AQUEDUCT.

The aqueduct was completed early in 1898, except for minor work which continued throughout the greater part of that year. During 1899 the most important work has been the extension of a small system of water supply constructed to supply water to a few families in West Berlin whose wells had been drained by the construction of the tunnel. The system of water supply completed late in 1897 proved somewhat unsatisfactory in 1898, apparently on account of the action of the water of the well from which the supply was derived upon the interior of the galvanized-iron pipe used to convey the water. In the latter part of 1898 the well was shut off and a supply obtained through the courtesy of the officials of the New York, New Haven & Hartford Railroad from works belonging to the railroad company. This water appeared to be satisfactory, though it passed for a considerable distance through the galvanized-iron pipe. It was therefore decided to seek a new source of supply, and the pipe line was extended 700 feet to a well dug at the site of a spring, a 2-inch iron pipe lined with cement being used for the

extension. The extension was made between May 15 and June 9, when water was turned on from the new well. The water seems to be satisfactory to the water takers.

CLINTON SEWERAGE.

A description of the works for the interception, pumping and disposal of the sewage of the town of Clinton is contained in the last annual report, and reference is there made to two contracts made early in September, 1898, as follows:—

SECTION 1. Filter-beds and appurtenances: contractor, Newell & Snowling Construction Company; amount of contract, \$21,162.62; date of contract, September 9, 1898.

SECTION 2. Intercepting sewer, reservoir, pumping station foundations and force main: contractors, Owen Cunningham & Son; approximate amount of contract, \$34,050; date of contract, September 8, 1898.

Section 1 was nearly completed at the end of 1898. Work was resumed on April 10, 1899, and was completed May 13. The principal items of work were:—

Earth excavation,	73,725.00 cubic yards.
Brick masonry,	88.90 " "
Concrete masonry,	67.22 " "
Furnishing and laying 24-inch vitrified pipe, .	1,179.60 linear feet.
Furnishing and laying 18-inch vitrified pipe, .	3,680.00 " "
Furnishing and laying 6-inch to 12-inch vitrified pipe,	3,454.20 " "

The maximum force employed by the contractors in 1899 was 29 men and 8 horses.

On Section 2, as noted in the last annual report, the junior member of the firm of Owen Cunningham & Son disappeared after collecting the money due from the November estimate, and on March 6, 1899, the senior member made a written statement that he was unable to continue the work. After consultation with the American Surety Company—the surety upon the bond for the performance of the contract—the Board advertised for bids for the completion of the work, and on March 23 a contract was made with Charles N. Taylor for the completion of the work. He began work by pumping the water from the partially completed reservoir on April 5 and completed the work August 17. The principal items of work under Mr. Taylor's contract were:—

Earth excavation,	12,454.50 cubic yards.
Rock excavation,	251.64 " "
Brick masonry,	140.95 " "
Concrete masonry,	1,205.65 " "
Stone masonry and paving,	163.29 " "
Furnishing and laying 20-inch and 24-inch vitrified pipe,	3,433.20 linear feet.
Furnishing and laying 6-inch vitrified pipe underdrain,	2,973.60 " "
Laying 16-inch and 18-inch cast-iron pipe,	517.80 " "
Spruce lumber in foundations,	14,544.00 feet B.M.

The maximum force employed by the contractor was 122 men and 6 horses. The amount of the final estimate was \$19,739.48.

The total amount paid out under the two contracts has been as follows :—

Payments to Owen Cunningham & Son,	\$10,041 15
Payments to laborers and others in connection with this contract,	4,235 43
Payments to Charles N. Taylor for completing section,	19,739 48
	<hr/>
	\$34,016 06

The amount that would have been payable at the prices stipulated in the original contract of Owen Cunningham & Son is \$34,082.96, so that there is a balance of \$66.90 still remaining unpaid under this contract.

Sewerage Pumping Station.

On May 29 a contract was made with Cutting, Bardwell & Co. for building the superstructure of the pumping station. The contractors began work in the middle of June and practically finished the building on August 19. It contains an engine room 22 by 25 feet, a boiler room 21 by 28 feet, a coal room 13 by 20 feet, and a screen and gate-chamber 12½ by 22 feet. Over the screen and gate-chamber there is a storage and work room. The chimney is 62 feet high and has a flue 2½ feet in diameter. The amount of the contract was \$5,499.54.

On April 8 a contract was made with the George F. Blake Manufacturing Company for furnishing and erecting a compound duplex pumping engine having a capacity of 3,000,000 gallons in twenty-four hours, after allowing 3 per cent. for slip, when operated against a total head of 55 feet and supplied with steam of not more than 80 pounds pressure at the throttle valve; the engine to perform a duty

of 50,000,000 foot-pounds for each 1,000 pounds of commercially dry steam supplied to the engine and its auxiliaries. The erection of the engine was begun on August 21. It was put in regular service on September 15 and was entirely finished on October 26. All of the sewage has been pumped to the filter-beds since September 15.

The pumping engine had somewhat more than the required capacity under the conditions above stated, and on December 19 a duty trial was made. The pumping engine was taken in its every-day condition and run at its full contract capacity, under which conditions a duty of 52,600,000 foot-pounds for each 1,000 pounds of steam was obtained. It is very probable that the engine, if specially adjusted for a duty trial, would give a higher duty. The price of the pumping engine was \$6,200.

In addition to the pumping engine, the station contains one 44-inch fire-box boiler which had previously been used for a short time at Mystic Lake, a Blake horizontal simplex vacuum pump which was furnished with the pumping engine under the contract, and a small receiver pump used for returning drain water from the cylinder jackets to the boiler and as an auxiliary feed pump. The boiler was covered with asbestos and magnesia by S. C. Nightingale & Childs. Provision has been made in the station for a second pumping engine and boiler, and it is expected that the second boiler will be added soon.

The 18-inch sluice gates and the 12-inch shear gates used at the filter-beds and at the pumping station were obtained from the Coffin Valve Company. The price for the sluice gates was \$44.50 each and for the shear gates \$12.10 each.

Settling Tanks, Bigelow Carpet Company.

One of the problems in connection with the sewerage of Clinton related to the disposal of the wool-washing wastes of the Bigelow Carpet Company. The wool when washed loses about 50 per cent. of its weight, and the wastes when allowed to run down Coachlace Brook into the river make the brook very foul and also pollute the river. It is consequently very desirable that the water from the washing machines should all be turned into the sewer, but that the solid matter should be retained as far as practicable at the works of the Bigelow Carpet Company. The company readily agreed to construct duplicate settling tanks for the removal of the solids in the place of a single tank already in use, which was not efficient. The



CLINTON SEWERAGE—FILTER-BEDS.

1. The first step is to identify the problem. This involves understanding the situation and the goals that need to be achieved.

Metropolitan Water Board cooperated to the extent of designing the tanks, supervising their construction and paying a small sum toward their cost, in order to retain a feature of the design which was thought hardly necessary by the company. These tanks are each 35 feet long and 8 feet wide, and are arranged to hold the water to a depth of 3 feet 9 inches. They are operating successfully, and measurements show that about 390 cubic feet of solid matter are removed per week by their use. A number of experiments were made before the tanks were built by collecting samples in large glass bottles, which showed that a part of the matter contained in the wash water would not settle at all readily. It was decided from these tests that it would be practicable to remove about 80 per cent. of the solids, and that the remaining 20 per cent. must be taken care of at the filter-beds. This material increases the difficulty of filtering the sewage, but the beds have continued to operate successfully ever since they were started.

Statistics of Sewerage Works.

Capacity of the Clinton sewerage reservoir, including the pump-wells, up to elevation 246.75, which is the highest level at which the sewage will stand in it without overflowing (gallons),	669,200
Length of 20-inch vitrified pipe intercepting sewer (feet),	3,661
Length of 24-inch vitrified pipe intercepting sewer (feet),	853
Length of 30-inch brick intercepting sewer (feet),	1,120
Length of 6-inch vitrified pipe underdrain beneath intercepting sewer (feet),	4,714
Diameter of steam cylinders of pumping engine (inches),	8 and 16
Diameter of plunger of pumping engine (inches),	16
Stroke of pumping engine (inches),	18
Length of 18-inch cast-iron force main (feet),	2,191
Length of 24-inch vitrified pipe leading from force main to filter-beds (feet),	1,180
Length of 18-inch vitrified distributing pipe (feet),	3,680
Length of 8-inch vitrified pipe underdrain beneath filter-beds (feet),	1,706
Length of 6-inch vitrified pipe underdrain beneath filter-beds (feet),	1,486
Aggregate area of 19 filter-beds from which all soil has been removed (acres),	17½
Aggregate area of 6 filter-beds from which but little soil has been removed (acres),	5½
Total area of filter-beds (acres),	23½

DRAINAGE OF SWAMPS.

The work of swamp drainage, which was begun in 1898 and is quite fully described in the last annual report, has been actively continued during the year 1899, and there has been no material change in the general policy of constructing ditches near the edges of the swamps to intercept the water from the uplands and convey it away before it comes in contact with the vegetable matter in the swamps, or in the method of constructing the ditches.

The work done by the dam and aqueduct department during the year 1899 has been as follows:—

Crane Swamp, the largest of the swamps tributary to the open channel, having an area, including Little Crane Swamp, of 460 acres, has been improved by the construction of ditches having an aggregate length of 45,250 feet. The watershed tributary to the outlet of this swamp is 2.9 square miles and the ditches vary in depth from 1.5 to 3.5 feet.

The swamps below and around Brigham's Pond have been improved, and the pond, which had an area of 14 acres with an average depth of about $2\frac{1}{2}$ feet, has been drained. The total length of ditches constructed in connection with this improvement was 11,811 feet.

In addition to these principal swamps, three other smaller ones have been improved by ditching. The total length of ditches constructed in 1899, in the territory tributary to the open channel, was 65,075 feet, which, added to the 15,231 feet constructed in 1898, makes a total length of 80,306 feet, equal to 15.2 miles. The total area of the swamps improved is 667 acres.

All of the work was done by a day-labor force which was employed continuously from the beginning of the year until November 23; from January to March the force was a small one, employed in clearing trees and brush from the land where it was proposed to construct the ditches. As the season advanced, so as to permit more active work, the force was increased, and on April 19 a second gang was organized. Both gangs continued at work until November 23, when the work was substantially completed, and one gang was discharged and the other transferred to the Wachusett watershed for similar work. The average force employed between April 19 and November 23 was 81 men and 6 horses.

In the case of Crane Swamp, which had a very large area owned

by many different owners, the land was purchased or taken by the Commonwealth, and the same policy was followed to a considerable extent in Little Crane Swamp. In nearly all other cases a permit for ditching the land has been obtained from the owners, and the land in its improved condition remains in their possession. These permits in nearly all cases provided that the ditches might be constructed and maintained without any payment to the owner of the land.

There has been a very decided improvement in the character of the water issuing from the swamps, as a result of the improvements which have been made.

At the outlet of Crane Swamp observations for four months after the completion of the work showed that the color was two-fifths of the color during the corresponding months in 1894. The water entering the open channel from the system of ditches constructed in 1898, but not wholly completed, had in 1899 one-third of the color that it had in the year ending in July, 1895. The past season has been such a dry one that these figures may not represent the results under ordinary conditions.

Swamps on the Wachusett Watershed.

On November 23 one force transferred from the work near the open channel began the improvement of a swamp in Boylston, and continued upon this work until the end of the year. The swamp where the work is being performed has an area of about 83 acres. The average force employed has consisted of 24 men and 2 horses.

NEW AQUEDUCT TO THE METROPOLITAN DISTRICT.

The report of the State Board of Health upon a Metropolitan Water Supply recommended prompt action in entering upon the construction of certain works for the water supply of the Metropolitan District, but also referred to a new aqueduct from the Sudbury Reservoir to the Metropolitan District, which should be ready for use in 1905 if all of the cities and towns within ten miles of the State House were included in the Metropolitan Water District. Some of these cities and towns have not entered the District, but the consumption of water has increased even more rapidly than estimated by the State Board of Health.

As it seemed probable that the new aqueduct would be required at, if not before, the time mentioned in the report, and a force

of engineers who had had experience in the location and construction of an aqueduct was available, it was thought best to undertake during the past year the surveys for this aqueduct. A small party has therefore been engaged upon this work since the early part of February. Many trial lines have been run and estimates of the cost of building the aqueduct upon them have been made, in order to determine where the aqueduct can be built with the greatest economy. These surveys were still in progress at the end of the year.

In addition to the surveys, soundings have been made by driving steel rods in 769 places to determine the location of the rock to be encountered. These soundings have an aggregate depth of 7,336 feet. Seven wash-drill borings have also been made, having an aggregate depth of 216 feet.

ENGINEERING AND MISCELLANEOUS.

Relocation of Central Massachusetts Railroad.

Additional surveys and estimates have been made for the relocation of this railroad. Two routes, which differ in part from routes previously considered, have been investigated and estimates of cost have been made.

Cement Tests.

In 1899 5,148 barrels of cement were used, the tests of which were made in the Clinton office. Of this cement, 1,422 barrels were American natural cement of the Hoffman brand, and 3,726 barrels were principally American Portland cements of the Iron Clad, Atlas and Lehigh brands. Including the cements used in 1899, the total number of barrels represented by the tests made from 1896 to 1899, inclusive, is 168,332. The summary of all tests will be found in Appendix No. 2.

SUDBURY DEPARTMENT.

DESMOND FITZGERALD, *Department Engineer.*

During the past year the work of construction in this department has related principally to the Marlborough Brook filter-beds and the draining of three swamps. These works are connected with the improvement of the quality of the water in that portion of the Sudbury watershed above Framingham Dam No. 3.

A considerable amount of work has also been done in grading the grounds below the Sudbury Dam and moving the office building.

The total cost of the construction of the Sudbury Reservoir and Dam to the end of 1899 was \$2,917,245.94.

The organization of the engineering force has been changed to correspond with the condition of the work. At the beginning of the year the force numbered 18 men and at the end of the year 12 men. Edward S. Larned has remained in direct charge of all of the work of construction. Walter W. Patch and Almon A. Platts have been assistant engineers throughout the year. Frederick Brooks, Daniel W. Cole, Benjamin F. Goodnough and William Smiddy have been assistant engineers on construction for a portion of the year. Mr. Brooks discontinued his connection with the works on May 27. Mr. Cole was transferred to the distribution department on April 20, and Messrs. Goodnough and Smiddy have been employed largely upon maintenance. Fred F. Moore is draftsman.

MARLBOROUGH BROOK FILTER-BEDS.

The plans for these filter-beds were completed early in the year, and the contract for their construction was awarded to Auguste Saucier on May 16.

The city of Marlborough is situated quite near to the Sudbury Reservoir and on its northerly side. A system of sewerage was introduced into the city a number of years ago, and the sewage removed to filter-beds located outside of the watershed from which the water supply is taken. A system of inspection was inaugurated by the city of Boston and has been maintained by the Metropolitan Water Board; but, notwithstanding these efforts to keep the water of the brook in good condition, it is at times of very bad quality, as it receives the washings of the streets.

The Marlborough Brook filter-beds were designed to filter the water of Marlborough Brook before allowing it to pass into the Sudbury Reservoir, and are so situated that the water will flow upon them by gravity. The beds are of sufficient capacity to filter a large run-off from the watershed tributary to the brook; this watershed has an area of 1.8 square miles.

A small settling reservoir was built in 1898 on the line of the brook below the city of Marlborough and immediately above the site of the filter-beds; here heavy matters are allowed to deposit before the water is turned upon the beds. Below the settling reservoir is an open channel about a half a mile in length, skirting the

beds at a higher level, which serves to distribute the water to subsidiary channels.

The filter-beds are separated into two divisions, the first consisting of 17 artificial beds and the second of 8 natural beds. Between the two groups is a storage bed having an area of 1.22 acres.

The total area of the artificial beds is 5.36 acres, the largest covering an area of 0.7 of an acre and the smallest an area of 0.07 of an acre, the average size being 0.33 of an acre. On the line of the main distributing channel there are two dams, by means of which the whole flow of the brook may be distributed to the artificial or natural beds, as desired. From the main channel there are four subsidiary channels, which distribute the water to the different beds. These channels are provided with concrete dams and inlets to the beds. The inlets for both the artificial and natural beds are of the same general form. They consist of a concrete wall with an opening 3 feet wide in the middle, controlled by stop-planks.

The artificial beds are filled with a thickness of 24 inches of sand, supported upon several layers of graded materials and screened gravel stones and underdrained by vitrified pipes. The beds are surrounded by embankments 2 feet in height. The flow is controlled in outlet wells furnished with movable weirs.

The area of the natural beds is 8.63 acres, each bed having an area of about one acre. The site of these beds was originally occupied by gravel knolls, the upper portions of which were removed to furnish material for the filling of the artificial beds. This material contained so much loam and other very fine material that the larger part of it had to be washed before being placed. After the upper material was removed the natural beds were formed by surrounding the excavated areas with low embankments. The filtered water from the natural beds is collected by pipes surrounding the beds and laid with filter joints; but there are no underdrains beneath the beds as in the artificial system. The work under this contract was substantially completed December 16.

During the severe drought of the past season the contractor used all the water of the brook for washing the sand for the artificial beds, and the effluent was afterwards filtered through the ground before reaching the reservoir. On the few occasions when there was a surplus of water it was filtered through such beds as were completed, so that the water of the brook has not been allowed to pass unfiltered into the Sudbury Reservoir since June.

The following table shows the quantity of work done and the cost of construction of these filter-beds :—

ITEMS.	Quantities.	Cost.
Earth excavation (in three classes) (cubic yards), . .	104,837.00	\$29,220 69
Rock excavation (cubic yards),	23.00	11 50
Portland cement concrete masonry (cubic yards), . . .	636.10	4,452 70
Brick masonry laid in Portland cement mortar (cubic yards),	30.45	426 30
Dimension-stone masonry (cubic yards),	11.28	315 84
First-class stone paving (cubic yards),	51.90	181 65
Second-class stone paving (cubic yards),	121.00	181 50
Vitrified pipe with open joints (6-inch to 15-inch pipe) (linear feet),	4,366.90	1,495 21
Vitrified pipe with cement joints (6-inch to 24-inch pipe) (linear feet),	2,171.60	1,328 63
Vitrified pipe with filter joints (10-inch to 20-inch pipe) (linear feet),	3,799.10	2,356 77
Day-labor work provided for in contract,	-	2,414 04
		<hr/> \$42,384 83

DRAINAGE OF SWAMPS.

The work of draining the swamps directly tributary to the Sudbury Reservoir and Framingham Reservoir No. 3 was begun on August 4 and continued throughout the remainder of the year. The ditches are of the same general character as those built in the portions of the watershed tributary to the open channel.

Angelico Swamp is the largest of the three swamps upon which work was undertaken during the year. It is situated mostly in the town of Southborough, easterly of the Sudbury Reservoir and close to the Sudbury divide. It contains a total length of 9,702 feet of ditching, nearly equally divided between meadow and woodland. Brewer Swamp lies in the towns of Framingham and Ashland and south of the Worcester turnpike, and contains 5,500 feet of ditching. Both of these swamps drain into Framingham Reservoir No. 3. Deerfoot Swamp, where the work of ditching is now in progress, is situated on the southerly side of the Sudbury Reservoir and on either side of the Worcester turnpike in Southborough. The length of ditching in this swamp to the end of the year was 5,100 feet, making the total length of ditch constructed by the Sudbury department 20,302 feet, and the total length in the Sudbury watershed

100,608 feet, equal to 19.1 miles. The total cost of the Angelico Swamp work was \$3,904.83 and of the Brewer Swamp improvement \$1,343.59. This work was done by a day-labor force averaging 39 men and 3 horses. The average cost per running foot was 34.5 cents; including land damages, 34.7 cents. The above prices are exclusive of engineering.

SPILLWAY WALL.

At the date of the last annual report work on this wall was in progress; it was completed on May 9. It forms one side of the permanent spillway channel which was excavated below the Sudbury Dam for the purpose of conducting the water which passes over the spillway of the dam into the brook channel. Owing to the bad condition of the rock upon which the wall is built, it was found necessary to excavate more of it than was originally intended; depressions in the bed of the channel were filled with rubble masonry. The work was done under a contract made last year with Mignault & McGrain, and the total cost was \$2,350.05.

BURNETT DRAINAGE DISPOSAL SYSTEM.

In making a settlement for the damages to the estate of the heirs of Joseph Burnett, the Board agreed to pay the sum of \$2,500 for restoring the water supply and sewerage systems which had been affected by the construction of the reservoir, or in lieu thereof to restore them for the owners of the property. The latter plan was followed, and work was begun by a day-labor force on November 14. The water in the upper end of the Sudbury Reservoir was drawn off and a lead pipe laid in a trench in the bottom of the reservoir, to replace one that had been removed during its construction.

The following is a brief description of the system of sewage disposal. From the Burnett mansion a 6-inch main pipe 491 feet in length was laid to a disposal area on the easterly side of the road which runs along the easterly side of the mansion house lot. Connected with this main a 6-inch branch 423 feet long conveys the sewage from the Lane house, so called, belonging to the same estate. The disposal area is circular in form, and the main pipe discharges into a centre well, the bottom of which is 2.75 feet below the bottom of the main pipe. From this well there are 16 radiating 6-inch tile pipes, each about 24 feet long, which are laid about 2 feet below the surface of the ground. Each pipe is surrounded for the greater part

of its length with screened gravel, having a maximum width at the outer end of the pipe of six feet and intended to facilitate the distribution of the sewage.

The effluent is to be collected by an 8-inch tile underdrain laid in a circle surrounding the bed, $3\frac{1}{2}$ feet below the level of the distributing pipes and at a distance of 14 feet from their outer ends. Most of the material found at the site of the filter-beds was suitable for filtration purposes, and where not suitable it was removed and sand and gravel were substituted. The work was completed December 8. The total cost of the water pipe was \$191.34 and of the sewage disposal system \$2,404.52, making the whole cost \$2,595.86. These figures include the cost of engineering.

FLASH-BOARDS FOR SUDBURY DAM.

The stone crest of the spillway of the Sudbury Dam is 1 foot below the ordinary high-water level. Early in the year the spillway was fitted with flash-boards about 1 foot in height. These are supported at intervals of 10 feet along the crest of the dam by cast-iron standards which can be securely fastened by means of keys into composition sockets made flush into the masonry of the dam. Standards are furnished with light posts which support a wire hand rail to add to the safety of the employes when placing or removing the planks, and it has been found that the planks can be readily removed when the water is level with the top of the flash-boards. The elevation of the top of the flash-boards is 159.97.

ENGINEERING.

The work of the engineering force during the year has been principally in connection with the works already described. In addition, however, surveys of swamps tributary to the Sudbury Reservoir have been made, and the work of tabulating and classifying the cost of water works taken from the city of Boston has been continued.

DISTRIBUTION DEPARTMENT.

DEXTER BRACKETT, *Department Engineer.*

The work in charge of this department comprises the pipes, distributing reservoirs, pumping stations and all other works in the Metropolitan District, with the exception of Chestnut Hill Reservoir and the grounds about it and the Sudbury and the Cochituate aqueducts.

The work of laying the pipes required to distribute water to the several cities and towns in the Metropolitan Water District was nearly finished in 1898, and the principal work of pipe-laying during the past year has been in connection with the supply of the town of Arlington, which was admitted to the District during the year.

The distributing reservoir in the Middlesex Fells for the supply of the northern high-service district has been completed. The low-service pumping station at Chestnut Hill Reservoir is approaching completion and the pumping machinery is being placed in position. The large pipes for conveying water from Chestnut Hill Reservoir to the pumps have been nearly all laid, and a gate-chamber has been partially constructed on the bank of the reservoir, containing gates for controlling the flow of water to the pumps. The northern high-service pumping station at Spot Pond has been so far completed that a pumping engine and boilers are now being placed in the building and will soon be in readiness for use. The work of improving and raising Spot Pond was begun in the summer and is now more than half completed.

The organization of the engineering force has remained nearly the same as during the previous year, but, on account of the large amount of work at Spot Pond, the number of men has been somewhat larger.

William E. Foss, John L. Howard and Caleb M. Saville have had charge of the engineering work in connection with the construction of reservoirs, pumping stations and pipe lines, and Will J. Sando has continued in charge of the construction and erection of engines, boilers and other machinery, and in addition has had charge of the operation of the pumping stations at Chestnut Hill and West Roxbury.

Alfred O. Doane has superintended the operation of the pumping stations in Malden, Somerville, Chelsea, Medford, Everett and Saugus, and the installation of recording gages, Venturi meters and pressure regulating valves, and has had charge of records of water consumption and of pipes received and delivered.

George E. Wilde, assistant superintendent in the distribution department, has continued in charge of the maintenance and operation of the pipe lines, reservoirs and other works within the Metropolitan District, with the exception of the pumping stations; and has, with the force under his charge, done considerable pipe-laying and other construction work.

The engineering force numbered 38 at the beginning and 53 at the end of the year; the average number employed was 47.

PIPES.

During the year three contracts and six orders have been given for pipes and special castings. Under these and under contracts made during the previous year 1,916 tons of pipes and 365 tons of special castings have been received during the year. Since the beginning of the work in 1896 77,978 tons of pipes and special castings have been received at the several pipe yards and 72,595 tons used, leaving 5,383 tons on hand at the present time.

PIPE YARDS.

At the Glenwood pipe yard, which is to be the permanent headquarters of the force in charge of the maintenance of the pipe lines and other works in the northern portion of the Metropolitan District, a two and a half story brick building, 101 feet 9 inches by 37 feet 8 inches, containing offices, stable and store-rooms, and a brick shed, store-room and blacksmith shop 109 feet by 21 feet, are now being built by W. L. Clark & Co. from plans made by Wheelwright & Haven, architects. Work on these buildings was begun about the middle of June, and at the close of the year the exterior of the office and stable building was practically finished and the greater portion of the interior finish was in place. The blacksmith shop and shed were also nearly completed.

Yards for the storage of pipes have been maintained near the Brighton station on the Boston & Albany Railroad, and near the Forest Hills station on the New York, New Haven & Hartford Railroad.

PIPE-LAYING.

During the year 3.50 miles of pipes have been laid, making a total of 67.33 miles now owned and operated by the Board in connection with the distributing system. The aggregate length of the pipes in the several cities and towns supplied either wholly or in part from the Metropolitan Works was at the close of the year 1,261.94 miles, making, with the pipes owned by the Board, 1,329 27 miles in the distributing system. Connected with the system there are 132,730 service pipes, 10,231 water meters and 11,616 fire hydrants.

The principal items of pipe-laying work done during the year have been the completion of the line for the supply of Nahant and Swamp-

scott, the laying of 3,195 feet of 24-inch pipes and 9,873 feet of 20-inch pipes for supplying the town of Arlington, and the laying of pipes for connections at the low-service pumping station at Chestnut Hill and the northern high-service pumping station at Spot Pond.

The pipes for supplying Nahant and Swampscott were laid during 1898, except at the crossing of the Saugus River between Saugus and Lynn, where the work was delayed on account of the proposed rebuilding of the bridge. Plans for the bridge having been adopted by the Lynn & Boston Railroad Company, an arrangement was made with that company to drive and cap the piles required for the support of the water pipes, and on April 8 a contract was made with Wm. H. Ryan & Co. for building the water pipe boxes and siphon. The construction of the siphon and pipe boxes was begun May 1 and the work completed on September 1. Crossing the bridge, the pipes, for a distance of about 470 feet, are enclosed in a double boxing, the inner box being 3 feet 9 inches wide and 2 feet high, made of spruce sheathing, and the outer box 4 feet 9 inches wide and 3 feet 6 inches high, made with bottom of 2-inch matched spruce plank and sides and top of clear white pine sheathing. The inverted siphon at the draw opening is 45 feet between the vertical legs, and the top of the horizontal portion at the bottom is $11\frac{1}{2}$ feet below Boston city base. It is built of 12-inch by 12-inch and 6-inch by 12-inch hard pine timbers, thoroughly bolted and keyed together, making a box 4 feet 8 inches by 3 feet 8 inches outside dimensions, in which the 20-inch pipes were placed and the box then filled with Portland cement concrete.

On account of the delay of the railroad company in completing the bridge approaches on both sides of the river, it was found necessary to lay 553 feet of 6-inch pipes and make temporary connections at both ends of the bridge, in order to furnish water to Nahant and Swampscott where the local supply was inadequate. The pipes on the bridge and in the street at either end, 953 feet of 16-inch and 113 feet of 20-inch, were laid by the maintenance force. The maintenance force also made the connections with and set pressure-regulating valves upon the pipes supplying Nahant and Swampscott.

A contract for laying about $2\frac{1}{2}$ miles of 24-inch and 20-inch pipes for the supply of Arlington was made with Bruno & Salomone on April 8. The work was begun April 20 and completed August 2. The work covered by this contract extended from a point in Jerome Street near the Mystic River in Medford, through Jerome and High

Streets in Medford, thence under the Mystic River and through Medford Street and Massachusetts Avenue in Arlington to the corner of Brattle Street. At the Mystic River the tops of the pipes were laid about 1 foot below the bed of the stream, which at the point of crossing is about 90 feet wide, with a maximum depth of 4 feet.

A contract for laying pipes from the corner of Massachusetts Avenue and Brattle Street to the pumping station lot, a distance of 760 feet, was awarded to H. A. Hanscom & Co. on September 7. Work was begun on October 24 and completed November 29. Two parallel lines of pipes were laid, a 20-inch line for supplying water to the pumps and a 16-inch line for connecting the pumps with the Arlington high-service pipe system.

One of the old 30-inch force mains between the Mystic pumping station and the reservoir, and a 36-inch pipe laid under the Mystic River for the purpose of conveying water from Mystic Lake to the pumping station, have been utilized as a portion of the pipe line for the supply of Arlington and Medford. The work of making the necessary changes in the connections at the Mystic River and pumping station, including the setting of a Venturi meter near the reservoir, also of setting a pressure-regulating valve on Massachusetts Avenue near Brattle Street and of connecting the supply and force mains with the pumps at the new temporary pumping station at Arlington, has been done by the maintenance force.

On Section 1, near the Chestnut Hill low-service pumping station, the maintenance force has laid about 800 feet of 48-inch pipes and made the force main connections with engine No. 1.

When the 48-inch main was laid through Massachusetts Avenue in Cambridge during the year 1897, plans for widening and rebuilding the bridge crossing the Fitchburg Railroad were under consideration, and a temporary crossing of the railroad was made with 24-inch pipes supported on a wooden bridge. The railroad company has during the past year rebuilt the bridge, and our pipes have been permanently located on the easterly side of the new bridge. The pipes crossing the railroad have been enlarged to 36 inches in diameter, and are supported by two steel plate girders, one of which also partially supports the sidewalk of the street bridge. These girders are 69 feet 7 inches long and are set 7 feet apart on centres, thus forming the sides of a box in which the pipes are laid, supported by 8-inch I beams, placed about 6 feet apart.

The steel girders were delivered by the New Jersey Steel and Iron

Company, and erected by the Fitchburg Railroad Company, during the month of November; and the work of laying pipes on the bridge and of making new connections with the pipes on either side was completed by the maintenance force on November 25. The wooden floor and roof of the pipe bridge have since been put in place by the maintenance force.

At the northern high-service pumping station the 36-inch force main in Woodland Road and the pumping station grounds, together with the connections for the Holly and Leavitt engines, have been laid by the maintenance force.

During the year additional connections have been made at the following points between the Metropolitan Water Works' mains and the pipes of cities and towns in the Metropolitan Water District: North Harvard Street, near Spurr Street in Brighton; Morton Street, at junction of Blue Hill Avenue in Dorchester; Morton Street, at junction of River Street in Dorchester; Beach Street, at junction of Pleasant Street in Revere; Nichols Street, at junction of Woodlawn Street in Everett.

SPOT POND.

Early in March it was decided that the work of cleaning and improving Spot Pond should also include the works necessary for raising the pond 9 feet above its present high-water mark, and the preparation of the necessary plans and specifications for the work and the superintendence of its construction have constituted the principal work of the distribution department during the past year. As the pond is situated within the limits of the Middlesex Fells Reservation of the Metropolitan Park System, the plans for the work have been made with special reference to landscape effect, and the detail plans for the grading, for the treatment of the shores and for the relocation of the roads were made by Olmsted Brothers, the well-known landscape architects, who have also supervised the work of tree-cutting around the pond.

The work, either completed or in progress, includes the excavation of all soil and mud from elevation 165, which is 2 feet above the new high-water level, down to elevation 142 in nearly all places where a clean sand or gravel bottom can be obtained at this elevation. Where the depth of mud is too great to permit this to be done, the mud surface exposed by lowering the pond to elevation 139.40 is covered with clean sand or gravel, generally to a depth of 12 inches.

If the mud surface is less than 16 feet below the water level when the pond is full, the mud is excavated to this depth before covering with gravel.

The raising of the pond necessitated the raising and relocation of $1\frac{1}{2}$ miles of streets and the building of 10 low dams or dikes, 3 of which are necessary to prevent the pond from overflowing at the main outlet and other low places, 2 separate the main pond from smaller ponds which are to be maintained at the same level but not used for water supply, and 5 prevent the water of the pond from flooding large areas of low land. Six of these dams have concrete masonry cores founded upon rock, 3 have earth cores of selected material, and 1, used to separate the main pond from the smaller pond on the west, will have no core.

The raising of the pond made necessary the building of a drainage system to divert into the outlet brook the water of the small streams which entered the northerly half of the pond. The water collected from about 800 acres, or 60 per cent. of the whole watershed of the pond, is now diverted.

In connection with the improvement a gate-chamber and inlet are under construction at the southern end of the pond to serve as a terminus for future pipe lines.

Preliminary Work.

The work of clearing trees and brush from the shores of the pond was commenced April 10, with a day-labor force consisting of a foreman and 20 wood-choppers. This force was increased, reaching a maximum of 45 about the middle of June, and the work was practically finished September 1. The small trees were cut off about two feet above the ground, and the large trees, after grubbing, were pulled over so that the stumps could be easily removed. About 80 acres were cleared, 1,030 cords of wood cut and piled and the brush piled ready for burning.

Between December 6, 1898, and May 17, 1899, the water was drawn off from the pond, lowering it about 12 feet, reducing its area and exposing nearly two-thirds of the bottom. Between May 17 and July 1 ditches were dug through the large areas of shallow flowage at the northerly end of the pond, in order to facilitate the draining and drying out of the material which was to be excavated. This work was done by a day-labor force, and over 13,000 cubic yards of earth were dug and thrown on the side of the ditches, at an average

cost of 15 cents per cubic yard. In the autumn the pond was drawn down to elevation 139.40, which was the lowest point to which it could be drained.

Drainage System.

As already stated, several low dams or dikes were constructed, to prevent the water of the pond, when raised, from flowing over areas of low land but slightly above the original high-water level of the pond. This necessitated a drainage system to prevent the water from accumulating upon the low lands outside of these low dams; but the drainage system was considered desirable, irrespective of this necessity, because the streams entering the northerly part of the pond drained a watershed which contained a portion of the town of Stoneham and several swamps which furnished water of unsatisfactory quality. This drainage system has its outlet into the brook, which is the natural outlet of the pond.

In the past the pond, on account of its large area, has modified the effect of freshets in the brooks tributary to it so as to materially diminish the rate of discharge at the outlet at such times; and, as it would be undesirable to turn water down this brook from the drainage system in larger quantity than it would have flowed from the pond, the drainage system was made of limited capacity, and it is also provided with gates, so that the flow through it can be restricted. It is the intention to prevent large freshets in the brook by storing the water temporarily in the low land outside of the dikes.

A contract for constructing the drainage system, consisting of 2,400 feet of 30-inch cast-iron pipes, a concrete conduit of horseshoe section 1,050 feet in length, 4 feet wide and 3½ feet high, 1,600 feet of 24-inch vitrified pipes and 2,200 feet of open channel, was made with C. E. Trumbull & Co. on June 8. The work was commenced June 12 and completed October 1.

Beginning the description at the lower end of the drain, which is just below the dam at the outlet of the pond, the drain consists of the 30-inch cast-iron pipe, which passes through the main dam, thence under the easterly portion of the pond and through one of the dams a short distance west of Pond Street. After passing through this dam it joins the concrete conduit which extends to a point a short distance north of Pond Street, where the section is again changed to an open channel which extends northerly to Doleful Pond. Another section of the drain connects Doleful Pond with the valley on the northwest side of the pond, and consists first of

an open channel, then of a section of 24-inch vitrified pipe laid most of the way under South street, and again of a section of open channel. The open channels were used where the drain was not in the streets, and the depth of excavation was small. They are constructed with a plank bottom 2 feet in width and with side slopes of 2 horizontal to 1 vertical, which were paved for a short distance up from the bottom planking. At each end of the cast-iron pipe valves are provided for controlling the flow of water, and screens and grooves for stop-planks were set where the water from the open channel sections flowed into the covered drains.

Concrete Core Walls.

Where the nature of the ground was such that a solid rock foundation could be obtained at a depth not exceeding 20 feet from the surface, it was decided to construct concrete core walls for the dams; and a contract for building five of these walls, including also a compacted earth embankment on each side of the walls, was made with the Brodhead Contracting Company of Easton, Pa., on June 19. The work was begun July 1 and completed December 1.

The following table gives the location of the dams and the lengths and heights of the several core walls:—

LOCATION.	Length of Core Wall.	Maximum Height of Core Wall.	Average Height.
Dam 1, outlet of pond,	621	25.0	15.3
Dam 9, near South Street,	188	10.2	6.3
Dam 10, near corner of South and Pond streets,	462	23.7	18.3
Dam 12, corner Pond Street and Woodland Road,	286	18.5	15.7
Dam 13, west of Main Street,	165	28.0	16.0

At Dam 1 the core wall is 3 feet thick at the top, and for 238 feet at the southerly end of the dam is built with vertical sides. For the remainder of its length, which includes the deeper portion near the gate-house, the wall has a batter of 1 in 6 on the down-stream face. The core wall of this dam is made of natural cement concrete, with the exception that for a length of 250 feet at the north end Portland cement concrete was used below elevation 150. The walls of all other dams have vertical sides, those at dams 10, 12 and 13 having a thickness of 2½ feet and that at Dam 9 of 2 feet. These walls are made of Portland cement concrete. All of the walls are

plastered on the side toward the pond with $\frac{1}{2}$ inch of Portland cement mortar, put on in two or more coats and rubbed to a smooth surface.

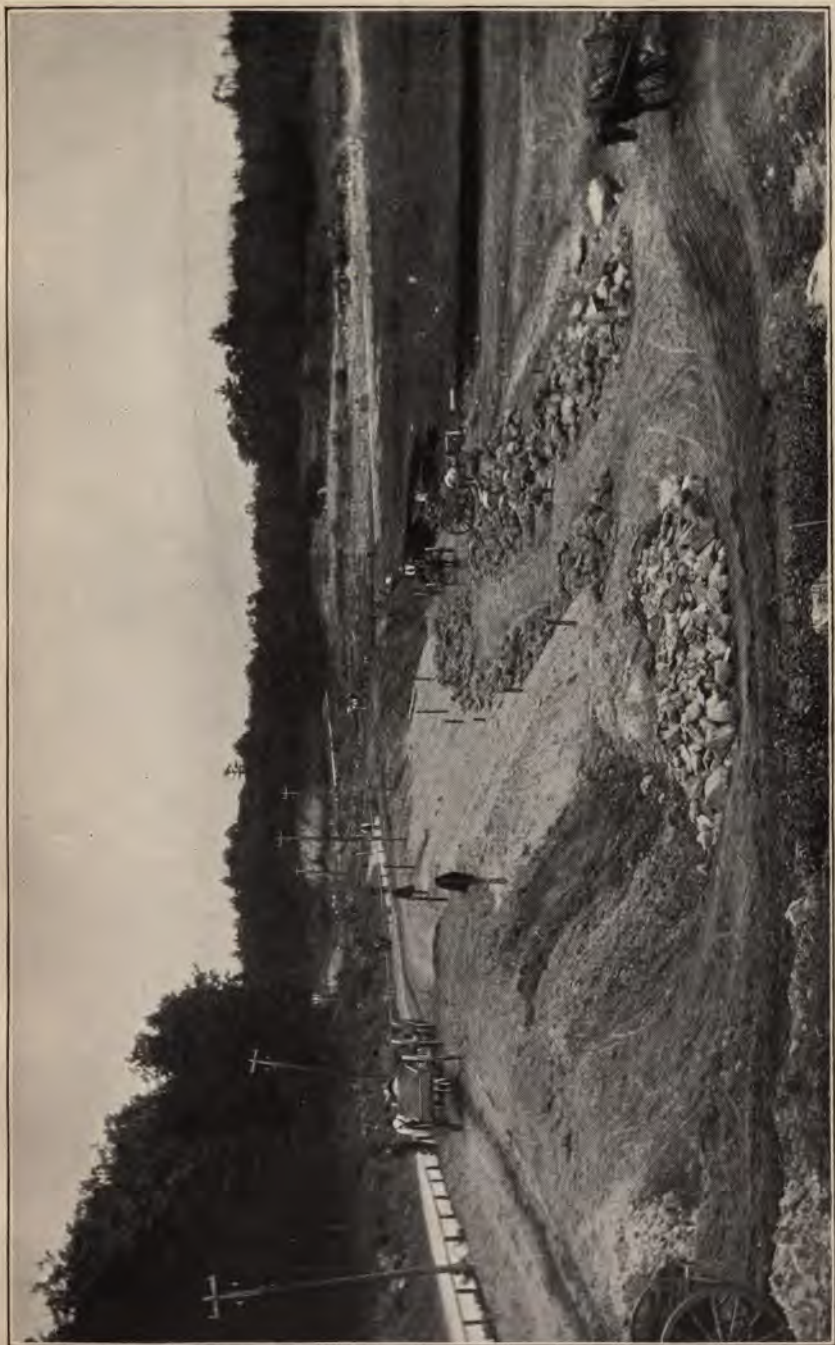
Excavating and Grading.

The work of excavating soil, mud, sand and gravel from the shores and bottom of the pond, constructing roads, earth dams and embankments, covering mud with sand and placing riprap on the shores, has been divided into seven sections. The work on sections 1, 2, 3, 4 and 6 is being done by contract. Section 5, which included only a small depth of excavation from quite a large area of rocky shores on the westerly and southerly sides of the pond and from two large islands, could not well be done by contract, and was done by H. P. Nawn, under an arrangement by which he furnished labor and tools and was paid 10 per cent. in addition to the actual cost of the work. A portion of the work on Section 7 has been done in connection with the contract for Section 1.

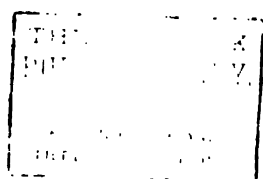
Table showing Approximate Quantities of Earth Excavation and Riprap Completed and Remaining to be done at the End of the Year.

	WORK COMPLETED DECEMBER 31, 1899.		WORK REMAINING TO BE DONE DECEMBER 31, 1899.		TOTAL WORK.	
	Earth Excavation (Cubic Yards).	Riprap (Cubic Yards).	Earth Excavation (Cubic Yards).	Riprap (Cubic Yards).	Earth Excavation (Cubic Yards).	Riprap (Cubic Yards).
Section 1, Newell & Snowling Construction Company, .	130,000	2,300	9,000	1,700	139,000	4,000
Section 2, Moulton & O'Ma- honey,	181,000	100	30,000	500	211,000	600
Section 3, Newell & Snowling Construction Company, .	71,500	75	141,500	1,925	213,000	2,000
Section 4, Moulton & O'Ma- honey,	78,000	1,300	147,000	5,500	225,000	6,800
Section 5, H. P. Nawn, . . .	60,000	9,000	—	—	60,000	9,000
Section 6, P. H. Fitzgerald, .	42,700	1,950	7,800	950	50,000	2,900
Section 7, Newell & Snowling Construction Company, .	11,000	—	21,000	3,500	32,000	3,500
Totals,	574,200	14,725	355,800	14,075	930,000	28,800

Section 1 is located on the easterly and northeasterly shores of the pond, between the outlet of the pond and a brook entering the pond from Cubby Hole Swamp. The work includes the raising and re-location of Woodland Road and Pond Street for a distance of about 2,600 feet, and at the northerly end of this section and across Sec-



SPOT POND—EXCAVATING MUD FROM BOTTOM OF POND AND GRADING SHORES.



tion 2, adjoining, a dam about 1,200 feet long is being constructed. Solid rock cannot be reached at a reasonable depth except for a short distance at either end, and a trench from 15 to 30 feet in width and 7 to 15 feet in depth has been excavated through the gravel and coarse sand to a layer of very fine sand or hard-pan. About one-third of the length of this dam is on Section 1, and on this section the trench has been filled with a very fine sand taken from the bottom of the pond, and a core of extremely fine sand about 15 feet in width has been built up to elevation 165, or 2 feet above the future high-water level of the pond. The fine material was spread in the trench in layers, and the lumps pulverized with a wheel-harrow.

Newell & Snowling Construction Company, with whom a contract for this work was made on July 19, began active operations on July 25, and at the close of the year the work was finished with the exception of the final surfacing of the roadways, a few thousand cubic yards of soil dressing and some riprap on the slopes.

Section 2 adjoins Section 1 on the north. Nearly all of the material excavated from the pond on this section, excepting the sand used for covering mud, is to be used in constructing a wide embankment or dike south of the Metropolitan Park office. The earth core through this embankment or dam is about 800 feet long, and was built in a manner similar to that previously described in connection with Section 1. The sand available on this section for building the core was not so fine as that found on Section 1, and mud from the pond was mixed with the sand for the purpose of making the core more nearly water-tight. It was found necessary to excavate the trench much deeper on this section than on Section 1, and for about 350 feet at the northern end of the dam the trench was carried down to about elevation 138, or from 20 to 22 feet below the original surface of the ground.

A contract for this work was made with Moulton & O'Mahoney on July 19, and the work was begun July 25. On December 31 about 80 per cent. of the work was finished, which is 25 per cent. in excess of the contract requirement.

Section 3 is located at the extreme northerly end of the pond. It includes the raising and relocation of 2,400 linear feet of South and Main streets, and the building of 900 feet of new roadway along the shore of the pond connecting the two streets. Near the junction of South and Main streets a trench about 1,000 feet in length is to be excavated to fine sand, and a core of fine material

constructed in a manner similar to that previously described in connection with the work on sections 1 and 2.

A contract for this work was made with the Newell & Snowling Construction Company on August 8, and the work was begun August 16. Only about one-third of the work was finished on January 1, but the contractors expect to continue work through the winter and intend to push the work to an early completion in the spring. About 1,200 feet in length of South Street, near its junction with Pond Street, have been raised and relocated, and the embankment completed and covered with soil.

Section 4 is located along the central portion of the west shore, and includes about 30 acres of mud and peat filled with stumps and logs. The work on this section also includes the raising, relocation and reconstruction of 2,260 feet of Main Street. At the west of Main Street a swampy area of about 13 acres is to be converted into a pond by a dam which has been built at the north end of the valley. This pond will be maintained at the same height as Spot Pond, but will be separated from it by an embankment on which Main Street is located.

A contract for this work was awarded to Moulton & O'Mahoney on August 8, and work was begun on the same day. The contractor has devoted his energies to the work on Section 2 and is behind the contract requirements on Section 4. About one-third of the work is done, however, and it is feasible to complete the work, as required by the contract, on or before July 15, 1900.

Section 5 includes the westerly and southerly shores of the pond for a distance of 5,000 feet, also two islands,—Great Island, so called, and a low area of about 10 acres which was exposed by lowering the water in the pond. The shores of the pond on the main land below elevation 154, which is the present high-water level, were on this section quite steep and generally free from mud. They were, however, very rocky, and beneath the rocks a layer of earth contained so much organic matter that it was desirable to remove it. This work, the removal of soil from between elevations 154 and 165, and the protection of the slopes after the removal of the soil, were of such a character that it was difficult to do the work by contract, and, as already stated, an arrangement was made with H. P. Nawn for doing the work, he to receive 10 per cent. in excess of its cost.

Work under this agreement was begun June 26, with a force of

about 50 men and 5 horses, which was gradually increased to a maximum of 176 men and 55 horses. After removing the stumps and roots, the soil was excavated from among the rocks and used in grading at Porter Cove, where Main Street was raised and relocated for a distance of 700 feet, and in filling coves at a number of points on the shore. The shore slopes where ledges were not exposed by the stripping were riprapped between elevations 158 and 165, and in many cases much lower, where it was necessary in order to provide a footing for the stones. Stones for the riprap were collected from the shores of the pond and from old walls near the work.

At Porter Cove and at several other points along the shore there were small areas of mud which have been covered with from 6 to 12 inches of sand. On Great Island there was a large shallow area between elevations 142 and 154, the surface of which contained considerable organic matter. From 6 to 8 inches in depth of material was removed from this area, as well as several areas of shallow mud along the shore. The material stripped from the shores, together with considerable mud brought from the low island south of Great Island, was used in building up a portion of the island which the new level of the water would have covered. The shores of the fill were covered with clean gravel and riprapped. On the low island lying south of Great Island there were about $6\frac{1}{2}$ acres of mud and $3\frac{1}{2}$ acres of gravelly hard-pan. The mud on about $2\frac{1}{2}$ acres of the area was so shallow that it was removed to hard bottom. The remainder of the mud was covered with the gravelly hard-pan obtained on the island.

In order to obtain easy access for teams to the islands from the main land, two temporary wooden bridges were built, one 170 feet long from the main land to the low island, and the other 150 feet long between the two islands.

Section 6 covers the shore about 700 feet northwesterly and 1,700 feet northeasterly from the old pumping station of the Medford Water Works, and the work includes the stripping of the shore, the building of a small earth dam, the building of a dam with a concrete core wall, a concrete masonry gate-chamber, and a double inlet conduit about 300 feet in length extending from the gate-chamber into deep water in the pond.

A contract for this work was made with P. H. Fitzgerald of New London, Conn., on August 24, and the work was commenced on September 4. At the close of the year the concrete masonry core

walls, gate-chamber and conduits, and more than four-fifths of the earth excavation, were completed. The gate-chamber contains two compartments with grooves for stop-planks and screens, and will be provided with valves for controlling the flow of water into and from the pond.

From the gate-chamber two conduits of horseshoe section extend about 300 feet into the pond. These are built one above the other in a monolithic structure of Portland cement concrete, the lower conduit being 8 feet wide and 5 feet 8 inches high, and the upper conduit 7 feet wide and 4 feet 5 inches high. The invert of the lower conduit is at elevation 137 and that of the upper conduit 143.67; but the inlet at the outer end of the upper conduit is arranged so as to draw water only from above elevation 151.

Two lines of 60-inch cast-iron pipes are to be laid from the gate-chamber toward the city of Medford. The present contract provides for laying 150 linear feet of each of these lines of pipe.

The core wall of the dam, about 400 feet in length, is founded on solid rock, and extends from the gate-chamber to the sides of the valley. It is built of natural cement concrete, 3 feet in thickness, with a plastering of Portland cement mortar.

Section 7 covers the work on the easterly shore from a point near the Melrose pumping station to the new inlet conduit near the new high-service pumping station, a distance of 2,300 feet. No contract has been made for work on this section, but Newell & Snowling have removed or covered all the mud on the shores in connection with their contract for Section 1, and have done considerable grading around the new high-service pumping station.

FELLS RESERVOIR.

The construction of this reservoir was begun in May, 1898, by T. W. Kinser & Sons, who were obliged to discontinue the work November 4, 1898, owing to financial troubles, after having completed less than half of it. A contract for completing the work was made with Nawn & Brock on November 4, and before the end of that year the masonry core walls of four of the dams were completed and covered with earth.

During the winter the work of excavating muck and rock from the bottom of the reservoir was continued, and early in April work was begun on the gate-chamber. The placing of concrete in the gate-chamber foundation was commenced April 15, and on July 10 the granite floor was finished in readiness for the superstructure. Frost remained in the ground until late in the spring, and it was not until April 20 that work could be resumed on the embankments. The work of placing concrete on the slope of Dam 5 was commenced on May 27, and on the bottom of the reservoir a few days later.

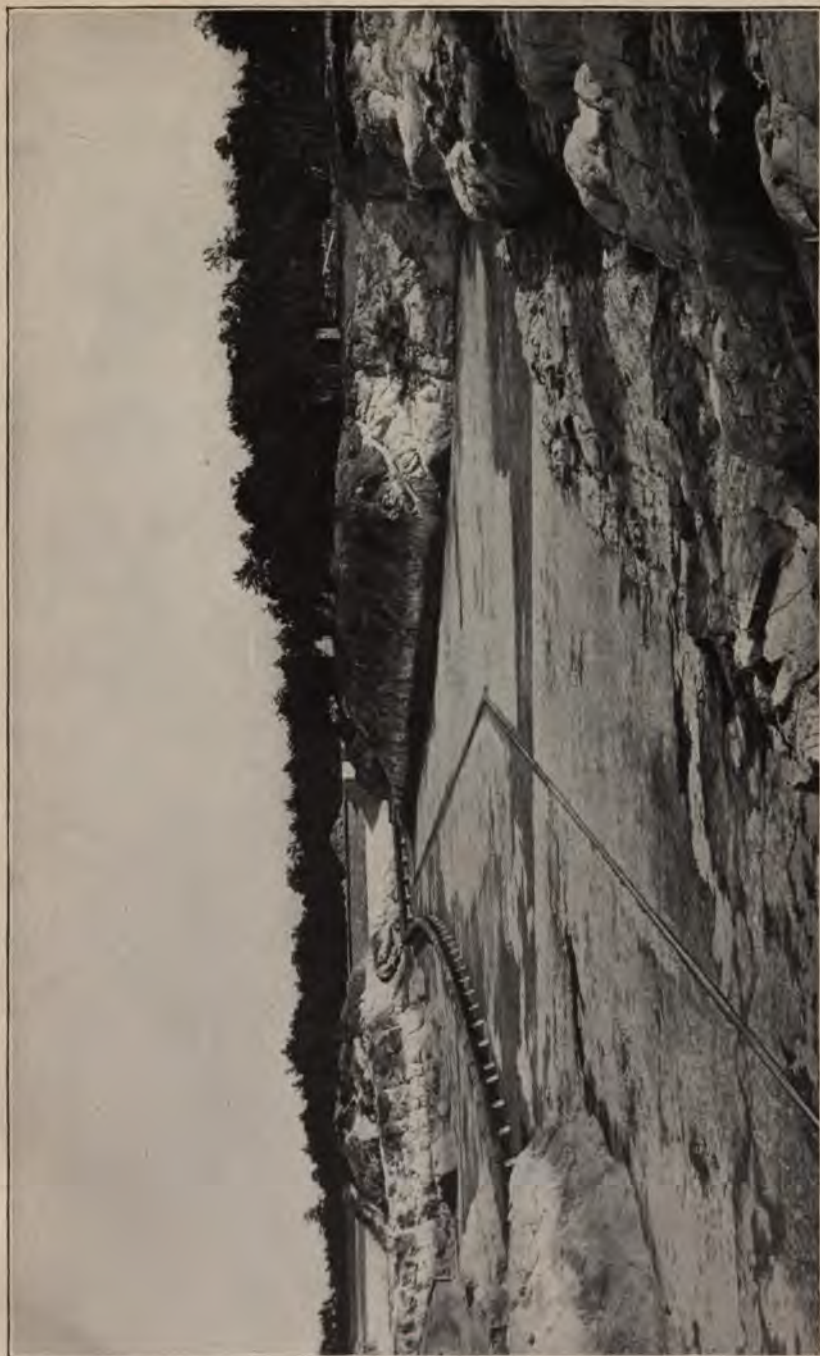
The work of concreting the bottom and slopes of the east basin was completed on August 10, and water was pumped into this basin on August 31. The west basin was placed in service on October 13, and the reservoir was filled to high-water mark on November 30.

As soon as the reservoir was finished the embankments were graded and sown with a mixture of grass seed and rye, and the roadway, 2,150 feet in length, giving access to the reservoir from the park roadway at the south, was graded and macadamized.

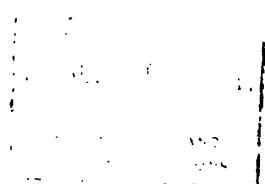
Nawn & Brock completed work under their contract on October 21.

The superstructure of the gate-chamber has been built by W. L. Clark & Co. in conformity with plans prepared by Shepley, Rutan & Coolidge, architects. The completion of the building has been delayed on account of the burning of the factory where the tiles for the roof were to be made, but they have lately been received, and the building is now practically finished.

This reservoir, which is the distributing reservoir for the northern high-service district, is situated in a natural rocky basin about 2,500 feet southeasterly from Spot Pond. By the construction of five dams having an aggregate length of 930 feet, the basin has been converted into a reservoir of irregular outline, which, when full at elevation



FELLS RESERVOIR—WEST BASIN BEFORE FILLING, WITH CONCRETE BOTTOM AND PIPE LINE.



271, has a water area of 8.5 acres and a capacity of 41,353,000 gallons. All of the dams have core walls of natural cement concrete 3 feet thick at the top, which are carried down with a batter of 1 in 12 on each side into the solid rock for their entire length. The tops of the walls are 2 feet above high water, and their heights vary from 15 to 34 feet. The faces of the walls next the reservoir are plastered with Portland cement mortar. Embankments of selected material, put on in 4-inch layers and rolled with grooved rollers or rammed, were built on both sides of each dam. On the side next the reservoir the embankments of four of the dams have a 4 to 1 slope of fine broken stone 10 inches in thickness, extending from elevation 272.5, which is 1.5 feet above high-water mark, to elevation 267; and below that point they have a 2 to 1 slope, covered with Portland cement concrete 4 inches in thickness. The bottom of the reservoir is at elevation 250 and is covered with 4 inches of natural cement concrete.

At elevation 265, or 6 feet below high water, the reservoir is divided by a natural ridge of rock and two walls of Portland cement concrete into two basins, the easterly of which has a capacity of 10,444,000 gallons and the westerly 15,359,000 gallons. The division walls are 6 feet wide at the top, and are carried down to solid rock with a batter of 1 in 8 on each side.

Water is to be supplied to the reservoir through a 36-inch force main, which enters the north end of the reservoir and is laid through the west basin, supported on concrete piers, to a gate-house at the south end of the reservoir. The portion of the gate-house below the ground level is built of Portland cement concrete, faced on exposed sides with granite to a point 6 feet below high-water mark. The structure contains 6 chambers provided with gates, so that the water can be delivered from the pumps into either basin or to the District, and can also be drawn from either basin independently. The gate-house also contains a measuring weir 6 feet in length for determining the capacity of the pumping engines, drainage valves, and a 16-inch overflow pipe connecting with a 16-inch drain pipe 600 feet long, which discharges into a swamp below the reservoir. The superstructure of the gate-house is built of seam-faced granite with trimmings of Deer Isle granite, and the roof is covered with red tiles.

Fells Reservoir, — Quantities and Cost of Work.

ITEMS.	WORK DONE BY T. W. KINSEER & SONS.		WORK DONE BY NAWN & BROCK.		Total Quantities.
	Quan- tities.	Price per Unit.	Quan- tities.	Price per Unit.	
Earth excavation (cubic yards),	56,033	\$0 19	56,750	\$0 51	112,783
Loose rock excavation (cubic yards),	523	0 50	974	0 90	1,497
Solid rock excavation (cubic yards),	5,132	1 75	3,370	1 50	8,502
Portland cement concrete (cubic yards),	-	5 50	1,817	7 00	1,817
Rosendale cement concrete (cubic yards),	1,965	3 95	2,708	5 25	4,673
Portland cement plaster (square yards),	859	0 25	540	0 75	1,399
Ashlar masonry (cubic yards),	-	20 00	37.70	20 00	37.70
Dimension-stone masonry (cubic yards),	-	75 00	15.57	50 00	15.57
Slope paving (cubic yards),	-	1 00	136	2 50	136
Laying 36-inch cast-iron pipe (linear feet),	187	1 00	1,050	1 25	1,237
Laying 16-inch and 12-inch cast-iron pipe (linear feet),	-	0 50	149	0 90	149
36-inch pipe joints run solid with lead,	2	2 50	2	2 50	4
16-inch and 12-inch pipe joints run solid with lead,	-	0 60	1	0 60	1
Earth excavation hauled each 100 feet over 1,000 feet (cubic yards),	-	0 01	3,849	0 01	3,849
Broken stone for covering slopes (cubic yards),	-	-	580	1 25	580
Amounts paid, including extra work,	\$35,038 48		\$68,836 40		\$103,874 88

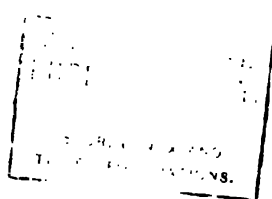
SOUTHERN HIGH-SERVICE PUMPING STATION.

The new Allis engine was started in December, 1898, and, although not entirely finished, it was used during the months of January and February at times when the consumption of water was very large on account of the cold weather. During March and April the magnesia covering was applied to the cylinders and steam pipes, and the steel lagging was placed on the steam cylinders. On April 13 the engine was placed in regular service, and has been run, with a few short interruptions, during the remainder of the year. The duty trial has not yet been made, but the record from week to week in regular service indicates that the contract requirements of 150,000,000 foot-pounds per 1,000 pounds of steam will without doubt be exceeded.

A contract was made with the American Stoker Company in January for placing mechanical stokers under two Belpaire boilers, and for furnishing and erecting a force draft plant to be used in connec-



FELLS RESERVOIR - DIVISION WALL BETWEEN EAST AND WEST BASINS, PARTIALLY FILLED.



tion with the stokers. The force draft plant, consisting of a B. F. Sturtevant Company's fan 7 feet in diameter, operated by a 6-inch by 6-inch horizontal side crank engine, together with the stokers for one boiler, was erected and started on June 26. The operation of the stokers was not entirely satisfactory when they were first started, but after changing the form of the coal hopper and readjusting the machinery they have worked very satisfactorily, and for the last three months of the year have operated continuously, saving coal and reducing the amount of smoke.

When all of the engines in the station are in operation, the conduit between the screen chamber and the pump-wells will not supply water to the pumps without an excessive loss of head; and, to obviate this difficulty, plans have been made for a connection 36 inches in diameter between the screen chamber and the pump well of the Allis engine. The pipes for this connection have been furnished by the Camden Iron Works, and the Atlantic Works are constructing a 36-inch sluice gate to be placed in the pump-well.

LOW-SERVICE PUMPING STATION.

The construction of this pumping station was begun on August 30, 1898, by Norcross Brothers, and at the end of that year the foundation walls were partially completed and the work of setting the granite base course of the engine-room superstructure had been begun. From January 1 to March 1 work on the building was practically suspended on account of severe cold and stormy weather. Work was resumed as soon as the weather was suitable, and the construction of the foundation walls and the erection of the superstructure were carried forward as rapidly as possible. The concrete foundations for the building, engines and boilers were completed on July 1. The steel work for the roof was delivered on July 3, and all the exterior stone and brick work was in place on October 1; but progress on the building during the past three months has been very slow, owing to delay in obtaining the cast-iron frames for the large windows in the engine-room. Three of these have within a short time been set in the rear of the building.

A contract for a travelling crane of 12 tons capacity for use in handling the machinery was made on March 31 with the New England Structural Company, for the sum of \$2,797, and the crane was erected in readiness for use on September 1.

The first shipment of castings for the three 35,000,000-gallon

engines was received from the Holly Manufacturing Company during the last week of the month of August, and the work of erecting the pumps was commenced as soon as the cars were unloaded. All of the pump castings for two of the engines are now in position, and the steam cylinders and other remaining parts of one of the engines will be shipped from the works of the Holly Manufacturing Company early in January. Work on the remainder of the second engine is well advanced at the shops, and it is expected that two of these engines will be erected in readiness for use during the coming summer.

On January 31 a contract was made with the Atlantic Works for three vertical fire-tube boilers 96 inches in diameter, contract price \$6,550 each. Two of these boilers have been delivered and are now being placed in position in the boiler-room, and the third boiler will be delivered at the station before the middle of January.

A contract was made on May 10 with the Fuel Economizer Company of Matteawan, N. Y., for furnishing and erecting a Green fuel economizer or feed-water heater, for the sum of \$1,643. This work has been completed.

On June 8 a contract was made with the Fitchburg Steam Engine Company to furnish an electric light engine, for the sum of \$741. Work on the engine is in progress at the shops.

On June 10 a contract for an electric generator and switch-board was made with the Westinghouse Electric and Manufacturing Company for the sum of \$1,346. The work has all been delivered at the station, but not placed in position.

Other contracts for work at this station, either in progress or completed during the year, are as follows : —

		Condition of Work.
Chapman Valve Manufacturing Company.	4 36-inch valves, contract price \$1,900,	Delivered.
Camden Iron Works, . . .	36 tons flanged pipes and castings, contract price \$3,528,	Delivered.
Atlantic Works,	8 40-inch sluice gates, contract price \$3,536,	Completed.
Moore & Wyman Elevator and Machine Works.	Plunger elevator for ash lift, contract price \$720,	In progress.
Boston Lightning Rod Company.	Lightning rods on chimney, contract price \$125,	Completed.
Chelmsford Foundry Company.	Cast-iron floor plates around engines, contract price \$961,	In progress.

GATE-HOUSE AND PIPE CONNECTIONS AT CHESTNUT HILL RESERVOIR.

In order to provide means for supplying water to the new low-service pumping station, and also to increase the supply into the pump-wells at the high-service station, a gate-chamber is now under construction on the shore of the reservoir nearly opposite the high-service station, and 48-inch and 60-inch pipes are being laid between the gate-chamber and the two pumping stations. Connections are also to be made with the Cochituate Aqueduct and with a 48-inch main leading from the terminal chamber of the Sudbury Aqueduct, so that water can be delivered from the aqueducts into the pump-wells at both stations without passing through Chestnut Hill Reservoir.

A contract for this work was awarded to Baker & Judson on August 7, 1899, and the work was commenced about two weeks later. The driving of piles for the coffer-dam, within which the construction of the gate-house was done, was begun on August 24; but the work progressed slowly, and it was not until October 7 that the water was pumped out of the inside of the coffer-dam and the work of excavation begun. Ledge was somewhat unexpectedly found from 1 to 3 feet above the elevation of the bottom of the gate-house foundations, and the removal of this rock delayed the work to some extent, so that it was not until November 2 that the placing of concrete was commenced. On November 27 the concrete walls of the gate-chamber were finished, and during the past month the granite floor stones have been set and 3 60-inch sluice valves on the outlet pipes have been set by the Atlantic Works.

The connections between the gate-chamber, the pump-wells at the two pumping stations, the Cochituate Aqueduct and existing pipes, comprising 625 feet of 48-inch and 1,160 feet of 60-inch pipes, were nearly all laid at the close of the year, but the work of making the final connections remains to be done.

Plans for the gate-chamber superstructure have been made by Wheelwright & Haven, architects.

NORTHERN HIGH-SERVICE PUMPING STATION.

A contract for this building and for the superstructure of a small gate-chamber at the inlet into Spot Pond was made with McNeil Brothers on January 7, 1899. The work of excavating was begun March 13, the first concrete was placed in the foundations on May 8,

and on May 27 the first stone of the superstructure was set. The contractor experienced great difficulty in obtaining steel beams for the roof trusses and other parts of the building, and it was not until December 1 that the roof of the engine-house was made tight with tarred paper. At the end of the year the exterior of the building was nearly finished.

A 12-ton travelling crane has been built and erected at the station by the New England Structural Company, for the sum of \$2,797. Early in November the work of moving the 10,000,000-gallon Leavitt engine from the old Mystic pumping station to this station was commenced. The engine had been previously taken down and the smaller parts boxed and packed. The work of transporting all the castings, including the bed-plate, weighing 25 tons, was done by R. S. Brine & Co. for the sum of \$1,125. The work of taking down the engine at the Mystic station and of setting it up in its new location has been done by our own employes under Mr. Sando's direction. It is expected that the engine will be in readiness for use by February 1.

Most of the castings and forgings have been made for the 20,000,-000-gallon engine, for which the Holly Manufacturing Company has a contract, and it is expected that the pump castings will be shipped from the works in March.

On May 8 a contract was made with the Lake Erie Boiler Works for three vertical fire-tube boilers, together with smoke-flues, galleries, feed piping, etc. The boilers are now in position in the boiler-room, and the flues, galleries and piping are being placed in position.

The Fuel Economizer Company is now erecting in the boiler-room a Green patent fuel economizer or feed-water heater, in conformity with contract made May 10, amounting to \$1,643.

Other contracts for work at this station, either in progress or completed during the year, are as follows : —

		Condition of Work.
Chelmsford Foundry Company.	Cast-iron floor plates around engine, contract price \$129,	In progress.
Boston Lightning Rod Company.	Lightning rods on chimney, contract price \$145, . . .	Completed.
Wheeler Condenser and Engineering Company.	Surface condenser, contract price \$725, . . .	Delivered.

NORTHERN EXTRA HIGH-SERVICE DISTRICT.

On April 20 proposals were received for a 2,000,000-gallon pumping engine for the northern extra high-service district, which at present includes only the higher portion of the town of Arlington. These proposals, ranging from \$20,750 to \$35,944, were all rejected, and it was decided to defer the purchase of the engine and the construction of a permanent pumping station until a more favorable price could be obtained for the engine. In order to comply with the request of the inhabitants of this portion of the town that they might be supplied with water from the Metropolitan Works, the pumps belonging to the town have been purchased and set up in a temporary wooden building, located on land which has been purchased as a site for a permanent station. This work is nearly finished, and the plant will be in operation within a few days.

SLUICE GATES, VALVES AND IRON FLOORS.

On February 28 a contract was made with the Coffin Valve Company for furnishing 20, 24, 30 and 36 inch valves, amounting to \$4,059.

Two contracts have been made with the Atlantic Works for furnishing and erecting sluice gates, the first, dated February 28, 1899, for 4 36-inch gates at the Spot Pond pumping station, for the sum of \$1,640; the second, dated June 23, 1899, for 3 60-inch gates with hydraulic lifts and 1 48-inch gate with screw lift at Chestnut Hill Reservoir, 2 60-inch gates with hydraulic lifts at southern gate-chamber at Spot Pond, 1 30-inch gate with screw lift on drainage system at Spot Pond, and 1 30-inch gate for use at Quincy Reservoir. The amount of this contract is \$8,986.

A contract for furnishing cast-iron stop-plank grooves and for furnishing and erecting cast-iron floor plates for gate-chambers at Spot Pond and Chestnut Hill, amounting to \$3,680, was made with the Coffin Valve Company on August 17. The stop-plank grooves have been delivered and work on the floor plates is about half finished at the shops.

An order for making and erecting at the southern inlet chamber at Spot Pond 2 60-inch regulating gates with lifting mechanism, for the sum of \$1,432, was given to the Coffin Valve Company on October 20. These gates have been delivered and will soon be placed in position.

MISCELLANEOUS.

Valves for automatically controlling the flow of water into the reservoirs at Chelsea and Revere have been set by the maintenance force. In each case a 6-inch balance valve was set on the inlet pipe, and this valve is to be opened and closed by means of a float in the tank, the water level in which is maintained at the same level as the surface of the reservoir. These valves will not be used until the pumping for the northern high-service district is done at the Spot Pond station.

In order to provide for obtaining a temporary supply of water in Watertown and Belmont in case of accident to the line of pipe between the pumping station at Chestnut Hill and the town of Watertown, a connection was made between the pipes of the town of Watertown and the city of Newton on Center Street, at the line between the two municipalities. The work was done by the maintenance force.

A 16-inch Venturi meter has been set in Broadway, Revere, on the main supplying water to Swampscott and Nahant, and one at the Mystic reservoir on a by-pass from the main supplying Arlington and a portion of Medford.

For the purpose of obtaining a continuous record of the water pressures in the mains of the distributing system, Crown pressure recording gages, made by the Jones Gage Company, have been established at the following points : —

Low-service mains : —

- Pumping station, Cedar Street, Somerville.
- Water works shop, Green Street, Malden.
- Pumping station, Park Street, Chelsea.
- Engine house, fire department, Harvard Avenue, Allston.
- Metropolitan Water Board office, 3 Mt. Vernon Street, Boston.

High-service mains : —

- Pumping station, Cedar Street, Somerville.
- Water department office, City Hall, Malden.
- Fire department building, Broadway, Revere.
- Water department, Adams Street, Milton.
- Metropolitan Water Board office, 3 Mt. Vernon Street, Boston.

ENGINEERING.

The following are the principal items of work upon which the engineering force of the distribution department has been engaged during the year : —

Surveys, plans, preparation of contracts and superintendence of construction of works for raising and improving Spot Pond, also for gate-chamber and pipe connections at Chestnut Hill Reservoir. In connection with the survey at Spot Pond 786 rod soundings aggregating 7,000 feet in depth, 280 wash drill borings aggregating 5,565 feet in depth, and 219 test pits were made for the purpose of ascertaining the character of material underlying the sites of several dams and the material to be excavated from the bottom of the pond.

Superintendence of construction of low-service pumping station at Chestnut Hill, of northern high-service pumping station at Spot Pond, and of the northern high-service reservoir in the Middlesex Fells ; surveys and plans and superintendence of work in connection with pipe line from the Mystic pumping station to Arlington, and the temporary pumping station for the Arlington high service.

Plans and specifications have been prepared for boilers, travelling cranes and fuel economizers for the Chestnut Hill and Spot Pond pumping stations ; for electric light machinery for the Chestnut Hill pumping station ; and sluice gates for use at Chestnut Hill Reservoir and Spot Pond. Detail drawings for the low-service engines at Chestnut Hill and for the engine at the high-service station at Spot Pond have been examined and approved.

The construction of all work of a mechanical character has been inspected at the shops where the work was done. An inspector has been stationed at the works of the Holly Manufacturing Company at Lockport during the entire year, and Mr. Sando and his assistants have inspected work at the following places : —

Atlantic Works,	East Boston,	Boilers and sluice gates.
Bethlehem Iron Company,	Bethlehem, Pa., . . .	Steel forgings.
Best Manufacturing Com-	Pittsburg, Pa., . . .	Steam piping.
pany,	East Cambridge, . . .	Pumping engine.
Geo. F. Blake Manufactur-	Dorchester,	Valves, sluice gates and
ing Company,	Chelmsford,	floor plates.
Coffin Valve Company, .		Floor plates.
Chelmsford Foundry Co., .		

Chapman Valve Company,	Indian Orchard, . .	Valves.
Camden Iron Works, . .	Philadelphia, Pa., . .	Castings.
Chester Steel Casting Com- pany,	Chester, Pa.,	Steel boiler castings.
Carbon Steel Company, . .	Pittsburg, Pa.,	Boiler plate.
Central Steel Company, . .	Harrisburg, Pa.,	Boiler plate.
DeLaney Forge,	Buffalo, N. Y.,	Steel forgings.
Davis & Farnum Manufact- uring Company,	Waltham,	Castings.
Fuel Economizer Co.,	Matteawan, N. Y.,	Fuel economizer.
Hoopes & Townsend,	Philadelphia, Pa.,	Bolts.
Lake Erie Boiler Works, . .	Buffalo, N. Y.,	Boilers.
Lorain Foundry Company,	Lorain, O.,	Pump castings.
New England Structural Company,	Everett,	Travelling cranes.
Osgood & Hart,	Charlestown,	Castings.
Westinghouse Electric and Manufacturing Com- pany,	Pittsburg, Pa.,	Electric generator.
West Point Foundry,	Cold Spring, N. Y.,	Engine castings.
Wheeler Condenser and Engineering Company, . .	New York, N. Y.,	Condenser.

OFFICE FORCE.

REUBEN SHIRREFFS and ALFRED D. FLINN, *Principal Office Assistants*; JOHN N. FERGUSON, *Office Assistant*.

Mr. Flinn succeeded Mr. Shirreffs as principal office assistant, in charge of the designing and drafting force, on February 20. The number of men in the department at the beginning of the year was 7 and at the end of the year 10, which is the largest number employed at any time. Two hundred and ninety finished plans have been made, also many studies, sketches and computations.

The studies, drawings and computations which have occupied the time of this department may be classified as follows:—

Wachusett Dam and its accessories and temporary protective works.

Wachusett Aqueduct: Record drawings of Assabet Bridge, culverts and highway bridges.

Clinton sewerage: Superstructure of pumping station and details of pumping plant and reservoir.

Sudbury Reservoir: Contour record drawings, Burnett estate sewerage, regulating shutter for gate-house inlets.

Sudbury Aqueduct: Stairs at Echo Bridge.

Marlborough Brook filter-beds: Regulating weir, tool-house and *miscellaneous* details.

Low-service Reservoir: Spot Pond improvement, Section 6, southerly and easterly gate-houses, details for drainage system and Quarter-mile Pond Bridge.

Low-service pipe lines: Bridge over Fitchburg Railroad, Massachusetts Avenue.

Gate-house and connections at Chestnut Hill Reservoir: New gate-chamber, connection chamber on Cochituate Aqueduct and pipe-line connections to pumping stations.

Chestnut Hill low-service pumping station: Miscellaneous details of building and machinery.

Chestnut Hill high-service pumping station: New connection between pump-well No. 4 and screen-chamber, forced draft and mechanical stoker for Belpaire boilers, record drawings of building, miscellaneous details.

Spot Pond pumping station: Changes in design of building, modification of Mystic and Melrose pumping engines, economizer and flues, and miscellaneous details of building and machinery.

Arlington extra high-service pumping station: Temporary station and pipe-line connections.

Fells Reservoir: Gate-chamber details.

Southern high-service reservoir: Reservoir, gate-chamber, water-tower and pipe-line connections on Forbes Hill, Quincy.

Sluice gates, 60-inch, 48-inch, 36-inch, 30-inch and 24-inch, circular, and 60-inch, square.

Valves, 30-inch hydraulic-lift, 24-inch check, and small plug drain valves.

Special castings and pipes.

Index systems for drawings and calculation books.

Specifications for several of the above items.

Mr. Ferguson has continued in charge of the miscellaneous work of the office, such as procuring supplies, making blue prints, filing plans and records received from outside offices, and has also made many investigations and computations.

MAINTENANCE.

In addition to the works maintained and operated in 1898, as enumerated in the last annual report, the maintenance and operation of the following works have been begun in 1899: Intercepting sewers, reservoir, pumping station and filter-beds of the Clinton

sewerage system in Clinton and Lancaster; the Marlborough Brook filter-beds in Marlborough; extensions of the pipe lines to Nahant, Swampscott and Arlington; the Fells Reservoir of the northern high-service system; and a pumping station at West Roxbury. In addition to these works, wholly controlled by the Metropolitan Water Board, the Commonwealth has paid the cost of the maintenance and operation of the pumping stations at Somerville, Malden, Medford, Everett and Saugus, which have been used to supply water for the northern high-service system; and the work at these pumping stations has been supervised by engineers connected with the maintenance force. The operation of the Melrose pumping station on the easterly shore of Spot Pond has been discontinued.

ADDITIONAL CITIES AND TOWNS FIRST SUPPLIED IN 1899.

The towns of Nahant, Swampscott and Arlington* were first supplied with Metropolitan water on June 30, 1899.

ORGANIZATION OF MAINTENANCE FORCE.

At the end of 1898 there was a total maintenance force of 121, exclusive of such of the engineers in the departments as devoted only a part of their time to maintenance. The details of this force were given in the last annual report. At the end of 1899 the maintenance force had been increased by 13, making a total of 134. The additions are due mainly to the additional works to be maintained, although in some instances there has been a slight increase in the force employed upon the works maintained in 1898. This maintenance force does not include a total of from 19 to 22 men in the pumping stations of the cities and towns as above enumerated.

RAINFALL AND YIELD.

The rainfall was very abundant, amounting to 16.10 inches on the Sudbury watershed, during the first three months of the year, and was correspondingly low on the Sudbury watershed during the remaining nine months, amounting to but 21.11 inches. As a result, the yield of the streams was very large for the first four months and very small for the remaining eight months of the year.

* Metropolitan water was not furnished to the high-service system in Arlington until January 3, 1900.

The record of the rainfall by months for the last nine months of 1899, in comparison with the record of the smallest rainfall for nine consecutive months, and the yield for the last eight months of 1899, in comparison with the smallest yield for eight consecutive months of a calendar year since the Sudbury watershed records were begun in 1875, is as follows:—

Comparison of Rainfall and Yield of Sudbury Watershed in 1899 with Previous Dry Periods.

RAINFALL ON SUDBURY WATERSHED.				YIELD OF SUDBURY WATERSHED (GALLONS PER DAY PER SQUARE MILE).			
DRIEST NINE MONTHS OF 1899.		DRIEST NINE CONSECUTIVE MONTHS BEFORE 1899.		DRIEST EIGHT MONTHS OF 1899.		DRIEST EIGHT CONSECUTIVE MONTHS BEFORE 1899.	
Month.	Rainfall (inches).	Month, 1883.	Rainfall (inches).	Month.	Yield.	Month. 1880-81.	Yield.
April, . .	1.90	January, . .	2.81	-	-	-	-
May, . .	1.45	February, . .	3.87	May, . .	511,000	-	-
June, . .	2.51	March, . .	1.78	June, . .	66,000	June, . .	175,000
July, . .	3.22	April, . .	1.84	July, . .	19,000	July, . .	176,000
August, . .	1.43	May, . .	4.19	August, . .	—35,000	August, . .	119,000
September, . .	3.95	June, . .	2.40	September, . .	94,000	September, . .	80,000
October, . .	2.69	July, . .	2.68	October, . .	115,000	October, . .	102,000
November, . .	2.18	August, . .	0.73	November, . .	304,000	November, . .	205,000
December, . .	1.78	September, . .	1.52	December, . .	220,000	December, . .	175,000
						January, . .	415,000
Total, . .	21.11	Total, . .	21.82	Mean, . .	162,000	Mean, . .	181,000

The rainfall record shows a smaller rainfall for a nine-months period in 1899 than ever before. The record of yield for eight months in 1899 also shows a smaller record than for any eight consecutive months since the Sudbury records have been kept. There is reason to doubt, however, whether the yield from the watershed was really smaller in 1899 than in 1880, because three reservoirs have been built in the meantime, which furnish additional evaporating surfaces. As a partial offset to the increased evaporation in 1899, Whitehall Pond furnished water in 1880 and 1883 to the river, of which no account was taken, as the pond was not then a part of the water system; whereas in 1899 it was a part of the system, and due allowance was made for changes in its level.

With a view to ascertaining which period was the driest, the yield of the river in the years 1880 and 1883, both of which were extremely dry, has been corrected for evaporation and for the flow from Whitehall Pond, so as to ascertain what the yield for these years would have been had the conditions been the same as in 1899. Taking these hypothetical yields, it is found that for five consecutive months the yield in 1899 would have been less than any previous year, but that for longer periods the yield in 1899 would not have been a minimum. The comparisons are shown by the following table:—

Comparison of Yield of Sudbury Watershed for 1899 with Corrected Yields of Previous Dry Periods.

PERIOD OF CONSECUTIVE MONTHS.	GALLONS PER DAY PER SQUARE MILE.		
	1880.	1883.	1899.
Driest five,	72,000	61,000	51,000
Driest six,	86,000	82,000	93,000
Driest seven,	103,000	106,000	111,000
Driest eight,	142,000	206,000	162,000
Driest nine,	183,000	305,000	232,000*

* The nine-months period includes the month of January, 1900.

Additional statistics relating to rainfall and yields of watersheds may be found in Appendix No. 3, tables 1 to 10.

STORAGE RESERVOIRS.

At the beginning of the year the water in the *Sudbury Reservoir* stood at elevation 253.39, which is 5.61 feet below the crest of the dam. It had been kept at a low level for constructional purposes during the preceding summer and autumn. In February the reservoir was nearly full. In April flash-boards about 1 foot in height were placed upon the crest of the dam, and the water was raised to the top of the flash-boards and remained substantially at this level until June 3, when the draft upon the reservoir began to exceed the supply. The water continued to lower to the end of the year, when it had fallen 15 feet.

The Marlborough Brook filter-beds, which are situated at the head of the northerly branch of the Sudbury Reservoir, were trans-

ferred from construction to maintenance on November 25, at which time an attendant was assigned to regular duties in charge of the beds, and they were used to filter all water which came down the brook to the end of the year.

Framingham Reservoir No. 3, which derives its supply almost wholly from the Sudbury Reservoir, was kept substantially full until August 26, when it was permitted to lower until the water was about 7 feet below the crest of the dam; and it was maintained at about this level until the latter part of October, when it became desirable to fill it in order to draw the Sudbury Reservoir to a lower level, to permit a pipe to be laid across one of its shallower arms.

At *Framingham Reservoir No. 2* the water was permitted to run to waste down the river until June 16, from which time until July 20 an average of 8,000,000 gallons per day was drawn from this source to prevent further waste. On August 25, when the water in the reservoir had improved in quality by a longer storage, a much larger quantity of water was drawn from this reservoir, but it was kept nearly full by running water into it from the Ashland and Hopkinton reservoirs.

Framingham Reservoir No. 1 was nearly full until December 23, when the water was drawn down about 10 feet, to permit repairs on the 48-inch pipe from Framingham Dam No. 3, which passes through this reservoir.

The *Ashland Reservoir* remained nearly full until about the first of September, after which time water was turned constantly from it into Framingham Reservoir No. 2 until November 11, when the water had been lowered to a level 32 feet below the crest of the dam.

The *Hopkinton Reservoir* remained practically full until the middle of September, after which time water was turned from it into Framingham Reservoir No. 2 until November 11, when the surface had lowered 25 feet. While drawing water from this reservoir, as much of it as could be efficiently filtered by the filter-beds below the dam was improved in this way.

Whitehall Reservoir has been kept practically full throughout the year, and has not been used as a source of water supply.

Farm Pond has been kept nearly full throughout the year. It lowered gradually during the summer, owing to the drought and

the operations of the Framingham Water Company, and was refilled from time to time, at the request of that company.

Lake Cochituate had been purposely lowered before the beginning of the year, so that water from Framingham Reservoir No. 3 could be run through the Sudbury Aqueduct into the lake, to improve the quality of the water. The quantity of the better water furnished to the lake in this way was 887,600,000 gallons. The waste from the lake ceased on July 11, but the surface remained substantially at high-water mark until July 28, when the quality of the water had improved so much that it was suitable for use. Water was drawn through the aqueduct to Chestnut Hill Reservoir from July 28 until November 6, when the water was again of such poor quality that the flow was stopped. During this time the surface of the lake lowered about 5½ feet.

The crest stones of the dam at the outlet of the lake, which were displaced by ice two years ago, were reset.

The filter-beds situated near the shores of Lake Cochituate and used for filtering the water of Pegan Brook have been in use 220 days throughout the year. In the first three months of the year the flow of the brook was extremely large, but no water entered the lake unfiltered, with the exception of a very small amount on the night of March 5. During the summer and autumn, on account of the drought, the flow of the brook was very small, so that it was not necessary to pump every day. In October pumping was necessary only on 7 days during the month. The total quantity of water pumped during the year was 219,186,000 gallons. The total amount of coal consumed was 210,230 pounds, making 1,043 gallons of water pumped per pound of coal.

The Pegan Brook receiving reservoir has been much improved during the year by filling in or deepening the shallow portions.

No water has been drawn from Dudley Pond during the year, but at the end of the year the surface was 3.34 feet below high-water mark.

The following table gives the quantity of water stored in the storage reservoirs at the beginning of each month. The second column gives the total in the reservoirs from which the supply is usually taken, the third column the storage in the other reservoirs and the last column the total storage in all the reservoirs.

Quantity of Water stored at the Beginning of Each Month.

DATE.	In Sudbury Reservoir and Framingham Reservoir No. 3 (Gallons).	In All Other Storage Reservoirs (Gallons).	Total (Gallons).
January 1, 1899,	5,644,100,000	6,731,800,000	12,375,900,000
February 1,	7,521,900,000	6,751,600,000	14,273,500,000
March 1,	7,850,500,000	5,834,900,000	13,685,400,000
April 1,	8,072,900,000	6,719,600,000	14,792,500,000
May 1,	8,311,100,000	6,975,200,000	15,286,300,000
June 1,	8,328,300,000	7,305,400,000	15,633,700,000
July 1,	7,615,300,000	7,195,500,000	14,810,800,000
August 1,	6,374,900,000	6,924,100,000	13,299,000,000
September 1,	5,065,300,000	6,351,000,000	11,416,300,000
October 1,	4,675,800,000	5,280,800,000	9,956,600,000
November 1,	4,885,800,000	3,598,100,000	8,483,900,000
December 1,	4,496,000,000	3,444,000,000	7,940,000,000
January 1, 1900,	3,077,200,000	3,851,200,000	6,428,400,000

NOTE. — The storage in Dudley Pond is included in this table.

SOURCES FROM WHICH WATER HAS BEEN TAKEN.

During the year the cities and towns supplied from the Metropolitan Works have taken very little water from local sources. Until June 16 the main supply was taken directly from Framingham Reservoir No. 3, which derives its supply mainly from the Sudbury Reservoir, which is in turn supplied from the Nashua River; and during the remainder of the year the larger part of the water was taken from this reservoir. At various times from June 16 to the end of the year water was drawn from Framingham Reservoir No. 2, in quantities ranging from an average of less than 2,000,000 gallons per day in June to 44,500,000 gallons per day in October, and the total quantity drawn averaged for the whole year 8,029,000 gallons per day. Between July 28 and November 6 water was drawn from Lake Cochituate, amounting to an average of 4,665,000 for each day throughout the year.

Owing to the unfinished condition of the works in the early part of the year, Spot Pond was the only source under the control of the Metropolitan Water Board from which water could be furnished

to the town of Melrose; and the water of the pond had a very disagreeable odor and taste, so that the supply was very unsatisfactory. It was found possible, on April 24, through the courtesy of the Malden Water Department, to open a connection between the pipes of Malden and Melrose, and to supply the town of Melrose from the main system after this date. Still later in the year the Fells Reservoir of the northern high-service system was completed and filled, and it was then feasible to supply the town from the main works without being dependent upon the Malden pipes.

After the admission of the towns of Nahant and Swampscott to the Metropolitan District, and at a time when much water was used for sprinkling lawns, on account of the dry season, a portion of the water supply for the northern high-service system was drawn from the sources of the Revere Water Company, by special arrangement.

The city of Medford furnished a part of its water supply during the early part of the year from local sources. The towns of Arlington, Nahant and Swampscott necessarily furnished their own supply from local sources until the Metropolitan water was introduced into these towns; and the town of Arlington continued to furnish water for its high service until the end of the year, pending the construction of a pumping station to supply the Metropolitan water.

A detailed statement of the sources from which the main supply was taken and the quantities of water supplied from local sources may be found in Appendix No. 3, tables Nos. 11 and 12.

AQUEDUCTS.

The *Wachusett Aqueduct* has been in continuous use throughout the year except for three days early in April, when the water was shut off in order to clean the aqueduct. The average daily flow for the whole year has been 62,975,000 gallons. At the time of cleaning the aqueduct a thin black deposit was found along the whole length of the aqueduct below the water line, and the gagings showed that this had diminished the carrying capacity of the aqueduct by an amount somewhere between 8 and 12 per cent. of the capacity when first used. After cleaning, the capacity became nearly as great as in the beginning. Since May 13 substantially all of the water in the river has been turned through the aqueduct, except that which the Metropolitan Water Act requires shall be permitted to flow down the river.

The *Sudbury Aqueduct* has been in continuous use throughout the year except on a few occasions for a day at a time, when it was necessary to empty it for cleaning or repairs. The total flow averaged for the whole year has been 84,716,000 gallons per day, which is about 14,000,000 gallons more than the daily amount of water run through the aqueduct last year. Owing to the necessity for the almost constant use of this aqueduct, and to the fact that for a considerable portion of the year its maximum carrying capacity is fully taxed, and also to the fact that Chestnut Hill Reservoir must be kept nearly full in order to supply water to the pumping stations, it becomes more and more difficult to put the aqueduct out of service for a sufficient length of time to thoroughly clean it or to make ordinary repairs.

On April 25 all of the track in the Rockland Street tunnel, 1,753 feet in length, was removed. This track was of wood, and was originally put in to guide the sweeping machine used in cleaning the aqueduct. After removing the track the bottom was thoroughly swept and about 5 cubic yards of debris were removed. On May 9 a similar track, 1,581 feet in length, was taken out of the Badger Hill tunnel.

In September the tar concrete surfacing of the Echo and Waban bridges was removed by the maintenance force, and replaced later by a granolithic surfacing laid by the Aberthaw Construction Company. The primary object was to obtain a surfacing which would be water-tight, so as to exclude rain water from the masonry. The tar concrete was very badly cracked and water passed freely through it into the masonry, and during the winter the effect of frost was such as to injure the upper part of the structures. The surface covered amounted to 756 square yards on Echo Bridge and 849 on Waban Bridge. After removing the tar concrete Rosendale cement concrete was laid to form a smooth surface upon which to lay the Portland cement granolithic, which was placed in a layer 4 inches in thickness over the whole length of the bridges. There is but one longitudinal joint, and that is in the middle, from which the surfacing slopes downward toward the sides. The contract for this work was made on September 25, and the company began work on October 2 and finished on November 7. The total amount of the contract was \$2,952.90. Before placing the granolithic the coping of the bridges was thoroughly pointed with elastic cement.

The leaks in the aqueduct on the Waban Bridge still continue to cause trouble, especially in the winter, when the water tends to freeze at the outlets of the drainage system, causing the water and ice to accumulate in the spandrel spaces. Last winter an effort was made to keep the outlets open during the coldest weather by the insertion of heated iron bars, which was partially successful.

The extreme drought of the past season gave an excellent opportunity for making a thorough overhauling of the siphon culverts along the line of the aqueduct, and they were thoroughly cleaned and repaired.

During the past season 201 stone bounds have been set or reset at the corners of the land of the Commonwealth; 124 of these were new bounds. A large amount of surveying was required to find the positions for these bounds, and in some cases to find old bounds which were hidden or buried, although correctly placed. A considerable amount of levelling was also done, for the purpose of establishing bench marks at manholes and other points through which measurements could be taken of the water in the aqueduct.

It has been found, in the Sudbury Aqueduct as well as in the Wachusett, that the frictional resistances are much greater when the surface is covered with slime than when it is clean, and observations show that the variation may be as much as 10 per cent. Careful current meter measurements of the flow have been made from time to time, especially when large quantities of water were flowing, and the hydraulic grade line for different flows has been established by observations at 29 stations along the line of the aqueduct.

The *Cochituate Aqueduct* was in use 102 days. The total quantity of water conveyed by the aqueduct averaged for the whole year 4,665,000 gallons per day. The interior was thoroughly cleaned in July, just previous to its being put into service. The brickwork was quite dirty, and a considerable amount of sponge was found growing on the interior. At this time four cracks were repaired easterly of Dedman's Brook, aggregating 1,568 feet. On November 13 the work of repairing the aqueduct was taken up in a more systematic manner, so that the aqueduct might be run under pressure if it should be found necessary from time to time with the increasing consumption of water in the District. It was particularly desirable to repair all of the cracks upon the embankments, *where leaks* from the aqueduct might lead to more serious conse-

quences than in other places. Accordingly a force of about 30 men was organized, and divided into three gangs for the purpose of making repairs. A large number of cracks have been thoroughly cut out and pointed with Portland cement. Where the cracks were very large, wooden wedges were used for maintaining the brickwork in place, and when the wedges were removed the spaces were filled with cement. In some cases it has been necessary to remove the brickwork to a width of 10 courses in order to make satisfactory repairs.

The following table shows the extent of the repairs to December 31, 1899:—

	Stations of Beginning of Crack.	Stations of End of Crack.	Length of Crack repaired (Feet).	Location of Crack.
Stevens' Brook embankment,	139.00	155+15	722	Top.
	141+20	155+15	1,395	Bottom.
	139+00	155+15	672	North side.
	139+00	155+15	594	South side.
Dedman's Brook embankment,	155+20	173+00	1,780	Top.
	155+20	169+00	856	North side.
	155+20	169+00	435	South side.
	157+27	158+01	74	Bottom.
	163+61	163+85	24	Bottom.
	166+67	170+30	351	Bottom.
	171+25.5	175+37.8	413.3	Bottom.
Newton Lower Falls embankment,	96+00	111+33	186	Top.
	96+00	111+33	771	Bottom.
	96+00	111+33	384	North side.
	96+00	111+33	448	South side.

While this work was in progress a small gang of men scraped and cleaned the interior of the four cast-iron siphon pipes which cross the valley of the Charles River at Newton Lower Falls, and 8½ cubic yards of iron rust and scrapings have thus far been removed.

On this aqueduct, as on the Sudbury, advantage was taken of the dry weather to pump out the culverts and remove the accumulated deposit. In April the city of Newton built a sewer, crossing under the Newton Lower Falls siphon on the easterly side of the Charles River. The work was difficult, on account of the presence of quicksand.

PUMPING STATIONS.

The pumping stations at Chestnut Hill Reservoir and West Roxbury and the Melrose pumping station at Spot Pond have been under the charge of Will J. Sando, superintendent of pumping stations, with a force of 29 men. The supervision of the operation of the small pumping stations at Chelsea, Somerville, Malden, Medford, Everett and Saugus, employing in all from 19 to 22 men, have been under the direction of A. O. Doane.

Chestnut Hill Pumping Station.

The machinery at this station has been used, as in 1898, to pump water both for the southern high-service and for the portion of the Metropolitan District north of the Charles River. Engines Nos. 1 and 2 for the entire year, and engine No. 3 for the greater portion of the last three months, were used to pump to the district north of the Charles River. The new Allis engine (No. 4) has, since its completion in April, pumped the greater part of the water used to supply the southern high service.

The following are the statistics relating to operations at this station : —

	LOW-SERVICE.		HIGH-SERVICE.		Total.
	Engines Nos. 1 and 2.	Engine No. 3.	Engine No. 3.	Engine No. 4.	
Total quantity pumped (million gallons), .	7,077.85	1,521.78	2,229.73	6,449.59	17,278.95
Total coal used (pounds),	4,258,987	779,471	1,984,095	4,816,728	11,839,281
Gallons pumped per pound of coal, . .	1,662	1,952	1,124	1,339	1,460
Average head pumped against (feet), . .	43.18	48.49	120.51	122.29	83.13
Cost of pumping :—					
Labor,	\$9,669 00	\$1,867 42	\$3,282 30	\$9,064 00	\$23,882 72
Fuel,	6,738 59	1,233 29	3,139 25	7,621 07	18,732 20
Repairs,	430 84	255 68	426 12	532 55	1,645 19
Oil, waste and packing,	204 10	74 47	129 60	364 35	772 52
Small supplies,	296 48	111 19	185 30	296 48	889 45
Total for station,	\$17,339 01	\$3,542 06	\$7,162 57	\$17,878 45	\$45,922 08
Cost per million gallons pumped to reservoir,	\$2.45	\$2.328	\$3.213	\$2.772	\$2.658
Cost per million gallons raised one foot high,	.057	.048	.027	.023	.032

The cost of operating the station compares favorably with that of the previous year; the quantity pumped shows an increase of 30 per cent., while the cost of pumping increased but 8 per cent.

The new Allis engine has been steadily increasing in efficiency.

The following statistics of cost of pumping at the Chestnut Hill and Mystic stations for the years 1896 and 1897, and of the cost of pumping at the Chestnut Hill station in 1898 and 1899, forcibly illustrate the large saving resulting from the abandonment of the Mystic pumping station on January 1, 1898; the reduction in height to which a portion of the water is raised; the increased efficiency of machinery used; and the greater economy per million gallons, due to pumping larger quantities of water.

YEAR.	Million Gallons Pumped.	Cost of Pumping.	Cost per Million Gallons Pumped.
1896,	9,557	\$64,196 04	\$6 72
1897,	9,818	57,895 21	5 89
1898,	13,238	42,507 48	3 21
1899,	17,279	45,922 08	2 66

During the year engines Nos. 1, 2 and 3 have been thoroughly overhauled and put in repair by employes at the station.

Coal has been purchased for use at the station as follows: —

John Morrison,	2,152.49 tons, at \$3.53 per ton.
Gillespie & Pierce,	294.22 tons, at \$3.45 per ton.
Loyal Hanna Coal and Coke Company, . . .	1,348.72 tons, at \$3.67 per ton.
Loyal Hanna Coal and Coke Company, . . .	710.31 tons, at \$3.48 per ton.
Loyal Hanna Coal and Coke Company, . . .	904.01 tons, at \$3.58 per ton.

Detailed statistics with regard to the operation of this station may be found in Appendix No. 3, tables 14 to 16.

West Roxbury Pumping Station.

Under an agreement made with the city of Boston, the maintenance of this station came under the control of the Metropolitan Water Board on February 1, 1899. It is located on the corner of Washington Street and Metropolitan Avenue, in West Roxbury, and contains two 10-inch by 7-inch by 12-inch Blake duplex pumps, and two 42-inch diameter vertical fire-tube boilers.

The pumps draw their supply of water from the pipes of the city of Boston, and raise it to a stand-pipe on Mt. Bellevue, from which it is distributed to the higher portions of the West Roxbury district. The daily average number of gallons pumped during the year was 304,000, — an increase of 3.6 per cent. over the amount pumped in the previous year.

The following are statistics relating to operations at this station for the year 1899 : —

Daily average quantity of water pumped (gallons),	. . . . .	304,000
Daily average quantity of coal consumed (pounds),	. . . . .	1,684
Gallons pumped per pound of coal,	. . . . .	180
Cost of pumping : —		
Labor,	. . . . .	\$2,609 34
Fuel,	. . . . .	1,493 60
Repairs and small supplies,	. . . . .	80 28
		<hr/>
		\$4,183 22
Cost per million gallons pumped to reservoir,	. . . . .	37 70
Cost per million gallons raised one foot high,	. . . . .	309

Melrose Pumping Station.

On account of the poor quality of the water in Spot Pond, the pumps at this station were stopped on April 24 and have not been since operated except for 22 hours on May 4 and 6 while repairs were being made on the pipe supplying the town of Melrose. Since the pumps were stopped the engineer of this station has been employed at the pumping station in Somerville, and the fireman has remained as watchman at the station.

Pumping for Northern High-service District.

Under arrangements made with the water departments of several cities in the northern high-service district, the pumping stations in Chelsea, Malden, Somerville and Medford for the whole year, and the stations of the city of Everett and of the Revere Water Company in Saugus for a portion of the summer while the consumption of water was very large, have been operated under the direction of the distribution department, and the cost of operation has been paid by the Metropolitan Water Board.

The pumps at the six stations above named have pumped the water used in Revere and Winthrop, and in the higher portions of Malden, Somerville, Medford, Everett, Chelsea and East Boston

for the entire year, nearly all of the supply of Melrose since April 24, a portion of the supply of Nahant and Swampscott from June 30 to August 21, and the entire supply of the two latter towns since that time. The Fells Reservoir was placed in service on August 31.

The quantities of water pumped and cost of operation at the several stations during the year was as follows:—

	Million Gallons Pumped.	Cost.	Cost per Million Gallons.
Malden,	895.80	\$13,172 49	\$14 71
Chelsea,	435.36	7,135 32	16 39
Somerville,	687.92	5,972 86	8 68
Medford,	228.33	4,327 56	18 95
Everett,	44.84	1,154 22	25 74
Saugus,	45.64	1,098 88	24 12

The cost of pumping the water has been high, as compared with the future cost of doing the work at the new station at Spot Pond, on account of the number of stations maintained and the low efficiency of the pumping machinery.

CONSUMPTION OF WATER.

The daily average quantity of water consumed in the cities and towns of the Metropolitan Water District, supplied wholly or in part by the Metropolitan Water Works during the year 1899, was 88,533,000 gallons, equivalent to 110 gallons per inhabitant in the district supplied. Of the above quantity, 87,143,000 gallons per day were supplied by the Metropolitan Water Works and 1,390,000 gallons per day from local sources. The increase in the daily average consumption of water in these cities and towns over that of the previous year was 9,259,000 gallons, or 11.7 per cent. A portion of this increase, estimated at 1.7 per cent. of the total, was due to the addition of the towns of Arlington, Nahant and Swampscott to the district supplied.

The remaining 10 per cent. is due in part to the natural growth in the consumption of water and in part to the different character of the years. Early in 1899 the weather was extremely cold, and much water was wasted to prevent the water pipes in houses from freezing. The summer was extremely dry, so that an unusually large quantity of water was used for sprinkling lawns. In 1898 the winter was not very cold, and the rains occurred so frequently in summer that very little water was used for sprinkling lawns.

The daily average consumption of water in the low-service district, including that drawn from Chestnut Hill by gravity, that drawn from the Spot Pond and Mystic Reservoir services, almost all of which was pumped at the Chestnut Hill station, and a small amount supplied from local services in Medford and Arlington, was 60,422,000 gallons, — an increase of 8.92 per cent. over that of the consumption of the same districts in 1898.

The daily average consumption of water in the northern high-service district, which embraces the city of Melrose, the towns of Revere, Winthrop, Nahant and Swampscott, and the higher portions of Somerville, Medford, Malden, Everett, Chelsea and East Boston, was 6,922,000 gallons; and that of the southern high-service, which includes the higher portions of the city of Boston (except the portion of the West Roxbury district supplied from the extra high service) and the whole of the city of Quincy and the towns of Watertown and Belmont, was 20,637,000 gallons. These two services show respectively percentages of increase of 47.3 and 9.5. The daily average consumption of water in the southern extra high-service district in West Roxbury was 304,000 gallons, and in the northern extra high-service in Arlington 248,000 gallons.

Detailed statistics of the consumption of water may be found in Appendix No. 3, tables 18 to 23.

QUALITY OF WATER.

Samples of water were collected each month from 17 points and each week from 3 points upon the works, and sent to the State Board of Health for analysis and examination. Samples of water are also collected each week from many points upon the works and examined microscopically and for color, odor and taste by the biological force of the Metropolitan Water Board. In addition to these weekly biological examinations, which are reported promptly and serve as a guide in the selection of waters to be furnished to the District, many special examinations are made to supply additional information regarding the best manner of operating the works so as to furnish the best possible quality of water at all times.

The conditions throughout the year have been favorable to supplying a water of good quality, and the water has been somewhat better than that furnished to the district during the last half of 1898 and very much better than the average of previous years.

A table which follows gives a comparison of the average results of examinations made for the years 1897, 1898 and 1899. The relative odor and taste of the water could not be tabulated, but there has been a continuous improvement from year to year in these respects as in others.

Comparison of Examinations of Boston Tap Water, 1897, 1898 and 1899.

	1897.	1898.	1899.
<i>State Board of Health Examinations.</i>			
Color (Nessler standard),	0.65	0.41	0.23
Total residue,	4.82	4.19	3.70
Loss on ignition,	1.84	1.60	1.80
Free ammonia,	0.0009	0.0008	0.0008
Albuminoid ammonia, { total,	0.0193	0.0152	0.0136
{ dissolved,	0.0177	0.0136	0.0122
{ suspended,	0.0016	0.0016	0.0014
Chlorine,	0.40	0.29	0.24
Nitrogen as nitrates,	0.0187	0.0097	0.0137
Nitrogen as nitrites,	0.0001	0.0001	0.0001
Oxygen consumed,	0.64	0.44	0.35
Hardness,	1.6	1.4	1.1
<i>Metropolitan Water Board Examinations.</i>			
Color (platinum standard),	0.59	0.40	0.32
Total organisms,	351	230	192
Amorphous matter,	177	131	201
Bacteria,	105	96	117

NOTE.—Chemical analyses are in parts per 100,000, organisms and amorphous matter in standard units per cubic centimeter, and bacteria in number per cubic centimeter. The standard unit has an area of 400 square microns, and by its use the number of diatomaceæ are decreased, and the number of chlorophyceæ and cyanophyceæ are very much increased, as compared with the number of organisms.

The Sudbury Reservoir and Framingham Reservoir No. 3, which derive their supply mainly from the Nashua River, furnish the best water; but, owing to the severe drought, it has not been feasible to furnish all of the water from these reservoirs. The water of Lake Cochituate had improved so much by July 28 that the water was practically as good as that in the Sudbury Reservoir, and consequently this source was used after that date until November 6, when the quality had deteriorated to such an extent that it was shut off.

It is a fortunate circumstance that when there is a severe drought the water of Framingham Reservoir No. 2, which is usually allowed to run to waste, improves very much in quality. As already stated, a small quantity was drawn from this source from June 16 until July 20, to prevent further waste, and this small quantity could be mingled with the other water without seriously affecting the quality of the water supplied to the city. By August 25 the water in this reservoir and in the Ashland and Hopkinton reservoirs above it had improved so much, owing to the long storage, that, although they

would not furnish water of as good quality as that from other sources, a large proportion of the water could be used from them without seriously affecting the quality of the water supplied to the consumers.

Appendix No. 3, tables 24 to 33, give the detailed results of chemical, microscopical and bacterial examinations of water from various parts of the Metropolitan Water Works.

BIOLOGICAL LABORATORY.

During the year 2,523 microscopical and 1,358 bacterial examinations of water were made at the laboratory of the Metropolitan Water Board, at 3 Mt. Vernon Street, Boston. Of the microscopical examinations, 1,971 were of the regular weekly samples and 552 were made in connection with special examinations.

The principal results of the work done by the biological force are given in Appendix No. 3; Table No. 31 gives the results of the microscopical examinations; Table No. 32, of the bacterial examinations; Table No. 33 gives the colors of the water; Table No. 34, the temperatures of the water; and Table No. 35, the temperatures of the air.

SANITARY INSPECTION.

As the Sudbury and Cochituate watersheds contain a large population, which renders the waters liable to contamination, two inspectors are employed to aid in maintaining the purity of the water. William W. Locke, C.E., is in charge of this work as sanitary inspector, and devotes a portion of his time to the inspection of the Wachusett watershed, supplementing the work upon that watershed of the medical inspector, who looks after the health of the force employed in the construction of the Wachusett Reservoir and the sanitary conditions of the camps of the contractors.

A summary of the work done in 1899 upon the Sudbury and Cochituate watersheds is given in the accompanying tables. The first table shows the number of premises inspected, a classification of the cases inspected and the condition of the premises at the end of the year. The headings of this table explain themselves except in a few instances; under the heading "Suspected" are included all cases where positive information could not be obtained, and where it is suspected that there may be some objectionable drainage; under the heading "Premises Vacant" are included all cases

which at present furnish no objectionable drainage, but which might furnish such drainage if the premises were occupied; under the heading "Unsatisfactory" are included all cases where there may be, under the most unfavorable conditions, wash from privies or direct sink drainage, all suspected cases and all cases of manufacturing wastes entering feeders, even though there may be some attempt at previous purification.

The second table shows the improvements effected in 1899. No cases are entered as remedied unless complete sewer connections have been made or all probability of future contamination has been removed, and no cases are entered as partly remedied except where positive improvement in the sanitary condition has been effected.

Summary of Sanitary Inspections in 1899.

DISTRICT.	Number of Premises Inspected.*	CLASSIFICATION OF CASES INSPECTED.									CONDITION AT END OF YEAR.	
		Cesspools dug before 1899.	Cesspools dug in 1899.	Direct Privy Drainage.	Indirect Privy Drainage.	Direct Sink Drainage.	Indirect Sink Drainage.	Manure Piles.	Manufacturing Wastes.	Premises Vacant.	Satisfactory.	Unsatisfactory.
<i>Sudbury Watershed.</i>												
Farm Pond,	3	1	-	-	-	-	-	1	-	-	3	-
Framingham Reservoir No. 3, .	7	4	2	-	-	-	1	1	-	-	7	-
Stony Brook,	64	25	19	-	-	2	6	10	1	3	54	10
Angle Brook,	417	256	1	-	4	16	85	31	-	29	342	75
Framingham reservoirs Nos. 1 and 2 and Cold Spring Brook, Eastern Sudbury,	25	13	8	-	-	-	7	3	-	1	22	6
Indian Brook,	36	18	-	-	-	-	8	4	-	12	31	5
Western Sudbury,	43	20	-	-	-	-	22	8	-	3	29	14
Whitehall Reservoir,	21	9	1	-	2	-	7	7	1	1	14	7
Cedar Swamp,	6	4	-	-	-	-	1	1	-	-	4	2
Totals,	46	27	5	-	-	-	8	1	1	1	41	5
<i>Cochituate Watershed.</i>												
Snake Brook,	27	17	2	-	-	-	7	4	1	-	22	5
Pegan Brook,	175	101	1	-	2	-	11	14	2	3	167	8
Course Brook,	8	5	-	-	-	-	4	-	-	-	6	2
Beaver Dam Brook,	93	53	7	-	3	-	17	12	3	4	76	17
Totals,	974	553	46	-	11	18	184	97	9	57	818	156

* Not including a large number of premises which were found on examination to be in a satisfactory sanitary condition, and likely to remain so. On some premises there are two or more cases.

Sanitary Improvements Effected in 1899.

DISTRICT.	Remedied by Sewer Connection.	Otherwise Remedied.	Partly Remedied.	Cesspools Abandoned on Account of Sewer Connections.
<i>Sudbury Watershed.</i>				
Farm Pond,	-	1	-	-
Framingham Reservoir No. 3,	-	-	2	-
Stony Brook,	-	3	10	-
Angle Brook,	14	1	3	9
Framingham reservoirs Nos. 1 and 2, and Cold Spring Brook,	-	-	7	-
Eastern Sudbury,	-	-	-	-
Indian Brook,	-	1	2	-
Western Sudbury,	-	-	1	-
Whitehall Reservoir,	-	-	-	-
Cedar Swamp,	23	-	5	23
<i>Cochituate Watershed.</i>				
Snake Brook,	-	-	4	-
Pegan Brook,	74	2	2	74
Course Brook,	1	-	-	1
Beaver Dam Brook,	34	1	13	34
Totals,	146	9	49	141

The results attained during the year have been very satisfactory. At the end of 1899 only about one-half as many "unsatisfactory" cases remained as at the end of 1898. The number of cases remedied by connection with sewers which discharge the sewage outside of these watersheds numbered 146 in 1899, against 53 in 1898; the number of cesspools abandoned was 141 in 1899, against 51 in 1898.

One of the more important sewer connections is that of the American Locomobile Company's factory on Beach Street in Westborough, where a receiving well and pump have been put in, and the sewage is now pumped into the town sewer instead of being allowed to filter into the brook as formerly.

The St. Mark's School filter-beds have been regraded and enlarged, so that the sewage is now disposed of in a more satisfactory manner than formerly.

The Deerfoot Farm factory filter-bed in Southborough has also been enlarged.

DISTRIBUTING RESERVOIRS.

The distributing reservoirs maintained by the Metropolitan Water Board are the Chestnut Hill Reservoir, Spot Pond, the Mystic distributing reservoir near Tufts College and the Fells Reservoir of the northern high service in the Middlesex Fells Reservation.

Chestnut Hill Reservoir.

The reservoir has been maintained in good condition. A 24-inch pipe drain about 300 feet long has been laid, at a total cost of \$802.64, near the influent gate-house, as a substitute for an open channel which had caved badly in places and required considerable work to keep it in repair. In November the tar concrete on the landing of the steps near the effluent gate-house, covering a portion of the basement of the gate-house, was removed, owing to its broken condition, which permitted water to percolate into the masonry, with consequent damage by freezing during the winter. A granolithic surfacing was substituted for the tar concrete. At the same time the steps at the gate-house and the curbing of the fountain just below were pointed with elastic cement.

During the extremely cold weather in February, when the Cochituate Aqueduct was not in use, it was impossible to supply as much water to the reservoir as was drawn from it. At this time the Lawrence basin was kept full, so as to maintain a full supply to the pumps, and the Bradlee basin was lowered to a level 4 feet below ordinary high water. During the latter part of the year one or both of these basins were kept from one to two feet below ordinary high water, to increase the amount which could be drawn from Lake Cochituate through the Cochituate Aqueduct, and as a measure of safety during the construction of a new gate-house.

Spot Pond.

At the beginning of the year the pond had already been drawn down 2.22 feet below high-water mark. During the month of January and the early part of February the water of the pond was used for the supply of the Metropolitan District, and it was then shut off on account of its inferior quality, but had to be let on again in a few days on account of the necessity for maintaining the supply during the extremely cold weather, when large quantities were

wasted to prevent freezing. The water was finally shut off on February 23, and no more water was used from the pond except for the town of Melrose, as already stated.

For a portion of January and February and during the months of March, April and May the water was wasted from the pond at several points in order to lower its level, and on June 1 the water had fallen to elevation 141.53, or 12.47 feet below high-water mark. It was lowered about 2 feet more during September, and until the early part of December was kept about 14.5 feet below high-water level. In order to provide a supply for use in case of emergency during the winter, about 180,000,000 gallons of water were pumped into the pond between December 5 and December 30, raising its surface to elevation 144.20 on January 1, 1900.

Mystic Reservoir.

The reservoir, gate-house and grounds are in good condition. The stairways leading to the reservoir have been painted and a portion of the roadway gravelled. Spot Pond having been shut off for the greater part of the year, this reservoir has been used to regulate the pressure of water in the district north of the Charles River, and two watchmen have been employed to make reports to the pumping station at Chestnut Hill of the height of the water in the reservoir.

Fells Reservoir.

One man has been employed at this reservoir since it was placed in service in November, to care for the gate-house and grounds, to remove leaves from the reservoir and to report the elevation of the water.

MYSTIC WORKS.

One man has been employed at the Mystic Lake, to care for the buildings and other property. The bridge over the outlet dam at the lake has been painted. At the Mystic pumping station engine No. 4 has been taken down and shipped to the new station at Spot Pond. The valves, check valves and pipes on the pumping station grounds, forming connections between the pumping engines and the force mains, have been taken up, and those suitable for use cleaned and painted. One room in the house occupied by the assistant superintendent has been used as an office for the department, and an attendant has been kept there at all times, both day and night.

PIPE LINES.

The maintenance and operation of the pipe lines, the pipe yards and the distributing reservoirs, with the exception of Chestnut Hill Reservoir, have continued under the immediate charge of George E. Wilde, assistant superintendent of the distribution department, with an average force of 26 men.

On June 29 the pipe line, about 6 miles in length, supplying water to Nahant and Swampscott, was placed in service; and on June 30 the pipe line supplying the town of Arlington was placed in service from the Mystic Reservoir to the corner of Massachusetts Avenue and Medford Street in Arlington.

The total length of the pipe lines now maintained in connection with the distributing system is 67.33 miles.

Forty-two leaks have been repaired on the pipe lines, only three of which were of serious character, and but one caused damage to adjoining property. The causes of leaks were as follows: —

Defective joints from various causes,	35
Joints blown out,	4
Broken pipes,	3

The most serious leak occurred about 5.15 P.M. on November 14, when a break occurred in the 36-inch high-service main in the Middlesex Fells Parkway in Malden, about 750 feet north of Highland Avenue. A large piece was broken out of one of the pipes, and the great flow of water washed away the surface of the parkway and adjoining streets, filled the catch-basins and drains with gravel and stones, and overflowed into several house cellars. The broken pipe was replaced on the following day, and the parkway and streets were repaired by the Metropolitan Park department and the street department of the city of Malden, at a cost of \$1,937.47.

On November 18 a leak was discovered in the 48-inch low-service main on St. Paul Street in Brookline, near Commonwealth Avenue. One of the pipes was found to be cracked for a length of about 3 feet, and the main was shut off and repaired the same day.

Quite a large number of leaks have occurred at the joints of the pipes crossing the Charles and Mystic rivers. Most of these have taken place in the fall and winter, and are apparently caused by contraction of the pipes and consequent opening of the ~~taper joints~~

which were used on some of these submerged pipes. On one case the lead was partially blown out of the bell, and the help of a diver was required in repairing the leak.

ARLINGTON STAND-PIPE.

Under an agreement made with the town of Arlington, the stand-pipe on Arlington Heights became the property of the Commonwealth when the town was admitted to the Metropolitan Water District. In August several leaks appeared in the bottom of the stand-pipe, and, upon emptying it, it was discovered that cavities of considerable extent existed under the bottom plate. It was thought probable that the leaks were caused by movements of the plates, and a consequent opening of the joints. Holes were bored through the bottom of the tank at nine points, and 40 barrels of neat Portland cement in the form of grout were pumped into the cavities. The holes were then plugged and the seams recalked and painted.

CLINTON SEWERAGE.

The act of the Legislature (chapter 557, Acts of 1898) relating to the Clinton sewerage system not only required the construction of works but their maintenance for an indefinite time. The plant has already been described under the head of construction. The works have been in daily operation since September 15. The regular force employed consists of one engineer at the pumping station, one attendant at the filter-beds and one additional employé, who assists both at the pumping station and at the filter-beds. When additional assistance is required, a force is transferred temporarily from other parts of the works.

The following are statistics relating to the operations at this pumping station:—

Daily average quantity of sewage pumped (gallons), . . .	500,100
Daily average quantity of coal consumed (pounds), . . .	1,025
Gallons pumped per pound of coal,	488
Number of days pumping,	108
Cost of pumping:—	
Labor,	\$369 75
Fuel,	222 91
Repairs and small supplies,	123 23
	<hr/>
	\$715 89
Cost per million gallons pumped,	13 25
Cost per million gallons raised one foot high,	27

Filter-beds. — The sewage has been applied almost entirely to the 19 filter-beds, from which all the soil was removed, and which have an aggregate area of $17\frac{3}{4}$ acres. Late in the season some of the beds were furrowed for use in the cold weather. Sewage has been applied to the beds generally at the rate of about 170,000 gallons per acre per application, and each bed has been used on an average of once in $4\frac{1}{2}$ days.

The works have operated successfully; but, as already stated, the wool-washing wastes from the works of the Bigelow Carpet Company add to the expense and difficulty of disposing of the sewage.

GENERAL STATEMENT.

In this portion of my report last year I called attention to the relation of the water consumption to the capacity of aqueducts, and gave a statement of the consumption of water in the Metropolitan Water District and Swampscott for the years 1890 to 1898, inclusive, together with the consumption in the same district for the next five years if the rate of increase should remain the same as from 1890 to 1898. I stated that the weather conditions in 1897 and 1898 had favored an abnormally low consumption of water, because the summers of both years had been unusually wet, so that it was not necessary to sprinkle lawns, and the comparatively mild winters had diminished the quantity of water wasted to prevent service pipes from freezing.

The year 1899 was, as already stated, one which favored an abnormally high consumption of water, and the actual consumption has exceeded that estimated on the basis of the consumption of 1898 by nearly 5,000,000 gallons per day.

The following table shows the average daily consumption of water in the Metropolitan Water District as constituted at the end of 1899, with the addition of Swampscott, which is to be supplied with water from the Metropolitan Water Works under the terms of a contract already made; also the estimated consumption in the same district for the years 1900 to 1904, upon the assumption that the rate of increase after 1899 will be the same as the average rate from 1890 to 1899: —

*Consumption of Water in the Metropolitan Water District and Swampscott,
1890-99.*

YEAR.	Water Consumption (Gallons per Day).	Population.	Consumption per Inhabitant (Gallons per Day).
<i>Actual Consumption, 1890-99.</i>			
1890,	47,555,000	648,802	73.3
1891,	52,676,000	668,665	78.8
1892,	57,687,000	688,528	83.8
1893,	65,590,000	708,391	92.6
1894,	64,782,000	728,254	89.0
1895,	68,882,000	748,117	92.1
1896,	77,688,000	772,300	100.6
1897,	80,144,000	796,800	100.6
1898,	82,914,000	821,000	101.0
1899,	91,299,000	845,800	107.9
<i>Estimated Consumption, 1900-1904.</i>			
1900,	96,159,000	-	-
1901,	101,020,000	-	-
1902,	105,880,000	-	-
1903,	110,741,000	-	-
1904,	115,601,000	-	-

NOTE.—The statistics given in this table include the whole Metropolitan Water District and Swampscott, while similar statistics already given in this report have included only the cities and towns supplied wholly or in part with water in 1899.

The figures given in the latter part of the table represent, as nearly as any estimate I can make, the quantity of water to be supplied through the aqueducts in the next few years. The estimated quantities are based largely upon the high consumption of water in 1899, and have included about 2,000,000 gallons of water per day which the city of Newton will probably continue to furnish from local sources, and for these reasons it might be thought that they are too high; but any error in this direction will be fully offset by the larger quantity of water which will be used in the low-service district of the city of Boston when the pressure in this district is increased by the operation of the new pumping station at Chestnut Hill Reservoir, and the additional quantity of water which will be used if additional cities and towns are admitted to the Metropolitan Water District.

In the report of the State Board of Health upon a Metropolitan Water Supply it was stated that the existing aqueducts would have sufficient capacity to supply the Metropolitan Water District with water until "the average consumption becomes 100,000,000 gallons per day in excess of what local sources will furnish." Upon this basis the capacity of the aqueducts would be reached in 1901. Since that report was made it has been decided to greatly increase the storage capacity of Spot Pond, and by thus providing a very large supply of water within the Metropolitan Water District it may be feasible to maintain the supply with the existing aqueducts until the average consumption becomes 110,000,000 gallons per day in excess of what local sources will furnish.

It is only by restricting the waste and misuse of water that the necessity for a new aqueduct ready for operation in 1903 can be avoided; and, as it does not appear feasible, under the existing conditions, to accomplish any large restriction in the waste and misuse of water, I regard it as imperative that the location and preliminary work for a new aqueduct from the Sudbury Reservoir to the Metropolitan Water District should continue to be actively prosecuted, and that the actual work of construction of the aqueduct should be begun in 1901.

Appended to this report are tables of contracts giving the amount of work done and other information, a statement of the cement tests made by the dam and aqueduct department, a long series of tables relating to the maintenance of the Metropolitan Water Works, tables showing the length of main pipes and number of service pipes, meters and fire-hydrants in the Metropolitan Water District, and a summary of statistics for 1899.

Respectfully submitted,

FREDERIC P. STEARNS,

Chief Engineer.

Boston, December 31, 1899.

APPENDIX.

APPENDIX No. 1.

CONTRACTS MADE AND PENDING

Contracts made by the Metropolitan Water

1. Num- ber of Con- tract.	2. WORK.	3. Num- ber of Bids.	AMOUNT OF BID.		6. Contractor.
			4. Next to Low- est.	5. Lowest.	
1	107* Section 3, Wachusett Reser- voir, excavating soil and building a road.	21	\$42,499 38	\$40,021 00†	T. H. Riddle & Co., New York, N. Y.
2	125 Excavation for easterly portion, North Dike. (The work under this con- tract was discontinued on account of financial troubles, and the remain- ing work was completed under the provisions of Contract No. 150.)	9	49,975 00	43,312 50†	Joseph D. Gennaro, Boston, Mass.
3	150 Excavating soil from Sec- tion 4 of the Wachusett Reservoir, and excavating and refilling at easterly portion of North Dike.	9	116,831 00	116,546 00†	Moulton & O'Mahoney, Boston, Mass.
4	152* Surfacing Section 1 of Boylston Street with broken stone, Boylston, Mass.	6	12,054 38	11,599 25†	Newell & Snowling Construction Co., Ux- bridge, Mass.
5	153* Surfacing Section 2 of Boylston Street with broken stone, Clinton and Boylston, Mass.	6	11,197 50	11,048 50†	Asa Goddard, Worces- ter, Mass.
6	154* Grading a portion of a rail- way in the Wachusett Reservoir, Clinton and Boylston, Mass.	10	3,090 00	2,838 00†	Moulton & O'Mahoney, Boston, Mass.
7	160 Excavating soil from part of Section 5 of the Wach- usett Reservoir, and ex- cavating and refilling at the westerly portion of the North Dike, Clinton and Sterling, Mass.	10	83,812 30	81,476 34†	Cenedella Brothers Milford, Mass.

* Contract completed.

† Contract based upon this bid.

APPENDIX No. 1.

DURING THE YEAR 1899.

Board relating to the Reservoir Department.

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1899.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1899.	
May 10, '98,	Oct. 1, '98,	Feb. 17, '99,	- -	\$52,456 96	\$52,456 96	1
Aug. 11, '98,	May 20, '99,	-	- -	36,219 59	36,219 59	2
Apr. 10, '99,	June 1, '00,	-	Clearing and grubbing, \$70.00 per acre; soil excavation, \$0.33 per cu. yd.; earth excavation, \$0.20 per cu. yd.	132,000 00	98,900 00	3
Apr. 7, '99,	Aug. 1, '99,	Aug. 23, '99,	Shaping surface of road-bed, \$0.07 per lin. ft.; broken stone in place, \$1.90 per ton.	11,869 83	11,869 83	4
Apr. 6, '99,	Aug. 1, '99,	Aug. 23, '99,	Shaping surface of road-bed, \$0.13 per lin. ft.; broken stone in place, \$1.80 per ton.	11,368 95	11,368 95	5
Apr. 6, '99,	May 10, '99,	July 5, '99,	Earth excavation, \$0.14 per cu. yd.; rock excavation \$0.38 per cu. yd.	2,894 83	2,894 83	6
June 1, '99,	Aug. 1, '00,	-	Clearing and grubbing, \$50.00 per acre; soil excavation, \$0.18 per cu. yd.; earth excavation, \$0.20 per cu. yd.; furnishing and laying sewer pipe: 4-inch, \$0.15 per lin. ft.; 8-inch, \$0.29 per lin. ft.; 10-inch, \$0.35 per lin. ft.; 12-inch for drains, \$0.38 per lin. ft.; 12-inch for culvert, \$0.60 per lin. ft.; 15-inch for drain, \$1.25 per lin. ft.; 24-inch for culvert, \$1.50 per lin. ft.; manholes, \$40.00 per manhole.	81,476 34	51,700 00	7

CONTRACTS MADE AND PENDING

Contracts made by the Metropolitan Water Board

1.	2.	3.	AMOUNT OF BID.		6.
			4.	5.	
Num- ber of Con- tract.	WORK.	Num- ber of Bids.	Next to Low- est.	Lowest.	Contractor.
1	161* Excavating soil and build- ing a road, West Boylston and Sterling, Mass.	13	\$18,392 95	\$17,840 75†	Peter J. O'Malley, Waltham, Mass.
2	164* Improving Lancaster Street, West Boylston, Mass.	8	6,308 50	5,890 60†	Thomas H. Gill, Somer- ville, Mass.
3	166 Excavating soil from Sec- tion 6 of the Wachusett Reservoir, and building the easterly portion of the North Dike, Boyl- ston, Clinton and West Boylston, Mass.	6	1,248,400 00	1,096,800 00†	Nawn & Brock, Boston, Mass.
4	176 Excavating soil from Sec- tion 9 of the Wachusett Reservoir, and building a road in West Boylston and Boylston, Mass.	7	48,666 40	35,848 25†	Busch Bros., Buffalo, N. Y.
5	183 Excavating soil from Sec- tion 7 of the Wachusett Reservoir, and building a part of the westerly portion of the North Dike, Clinton and Boyl- ston, Mass.	5	238,500 00†	230,685 00	Long & Little, Leom- inster, Mass.
	Total, . . . .	. . .	. . . .	. . . .	. . . . .

Contracts made by the Metropolitan Water Board

6	37* Section 11, Wachusett Aqueduct, open channel, 16,800 feet in length, with two small masonry dams and several stone arch bridges.	21	\$89,470 00†	\$86,960 00	Moulton & O'Mahoney, Boston, Mass.
7	127* Section 1, Clinton sewer- age system, filter-beds.	12	19,022 20†	18,709 00	Newell & Snowling Construction Co., Ux- bridge, Mass.

* Contract completed.

† Contract based upon this bid.

DURING THE YEAR 1899 — *Continued.**relating to the Reservoir Department — Concluded.*

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1899.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1899.	
June 2, '99,	Sept. 1, '99,	Nov. 20, '99,	Earth excavation, \$0.24½ per cu. yd.; rock excavation, \$1.25 per cu. yd.; slope paving, \$0.90 per cu. yd.; rubble masonry laid dry, \$1.50 per cu. yd.; rubble masonry laid in mortar, \$4.00 per cu. yd.; split-stone masonry laid in mortar, \$20.00 per cu. yd.	\$20,166 28	\$20,166 28	1
June 3, '99,	Aug. 15, '99,	Nov. 20, '99,	Earth excavation, \$0.29 per cu. yd.; rock excavation, \$1.00 per cu. yd.; dry paving, \$3.00 per cu. yd.; rubble masonry, \$3.50 per cu. yd.; split-stone masonry, \$14.00 per cu. yd.	8,438 87	8,438 87	2
June 18, '99,	Dec. 1, '02,	-	Clearing and grubbing, \$70.00 per acre; soil excavation, \$0.26, \$0.31 and \$0.35 per cu. yd.; earth excavation, \$0.18 per cu. yd.; gravel excavation, \$0.18 per cu. yd.	1,096,300 00	55,500 00	3
July 29, '99,	May 1, '00,	-	Earth excavation, \$0.20 per cu. yd.; rock excavation, \$1.00 per cu. yd.; slope paving, \$1.50 per cu. yd.; rubble masonry laid dry, \$3.75 per cu. yd.; rubble masonry laid in mortar, \$4.00 per cu. yd.; split-stone masonry laid in mortar, \$10.00 per cu. yd.; laying 12-inch sewer pipe for culverts, \$0.60 per lin. ft.	35,843 25	24,400 00	4
Dec. 12, '99,	July 1, '03,	-	Clearing and grubbing, \$60.00 per acre; soil excavation, \$0.30, \$0.32 and \$0.35 per cu. yd.; earth excavation, \$0.25 per cu. yd.; gravel excavation, \$0.27 per cu. yd.	238,500 00	-	5
. . . . .	. . . . .	. . . . .	. . . . .	\$1,727,534 90	\$373,915 31	

relating to the Dam and Aqueduct Department.

Sept. 22, '06,	Dec. 1, '07,	Apr. 12, '09,	-	-	\$170,050 32	\$170,050 32	6
Sept. 9, '08,	May 15, '09,	June 24, '09,	-	-	21,162 62	21,162 62	7

CONTRACTS MADE AND PENDING

Contracts made by the Metropolitan Water Board

1.	2.	3.	AMOUNT OF BID.		6.	
			4.	5.		
Number of Contract.	WORK.	Number of Bids.	Next to Lowest.	Lowest.	Contractor.	
1	128	Section 2, Clinton sewerage system, intercepting sewer, reservoir, pumping station foundations and force main. (Work abandoned and remaining work relet—see contract No. 147.)	12	\$29,861 80	\$29,389 50†	Owen Cunningham & Son, Somerville, Mass.
2	147*	Section 2, Clinton sewerage system, intercepting sewer, reservoir, pumping station foundations and force main (second letting).	15	16,281 00	15,642 00†	Charles N. Taylor, Natick, Mass.
3	149*	Pumping engine for the Clinton sewerage pumping station, in Clinton, Mass.	1	-	6,200 00†	George F. Blake Mfg. Co., New York, N. Y.
4	162*	Superstructure of Clinton sewerage pumping station.	8	6,475 00	5,482 00†	Cutting, Bardwell & Co., Worcester, Mass.
5	168*	Preliminary excavation and masonry for the Wachusett Dam, Clinton, Mass.	11	14,300 00	12,770 00†	Busch Bros., Buffalo, N. Y.
		Total,				

Contracts made by the Metropolitan Water

6	15*	Section O, Sudbury Reservoir.	12	\$151,113 00	\$186,040 00†	Washburn & Washburn, New York, N. Y.
7	17*	Section Q, Sudbury Reservoir.	14	123,690 00†	115,010 00	Washburn & Washburn, New York, N. Y.
8	138*	Spillway channel, Sudbury Dam.	2	2,283 00	1,892 00†	Mignault & McGrain, South Framingham, Mass.
9	157*	Marlborough Brook filter-beds.	8	40,670 50	39,918 40†	Auguste Saucier, South Framingham, Mass.
		Total,				

*Contracts made by the Metropolitan Water Board***Water Pipes.**

10	120*	185 tons special castings, .	2	\$37.00 per ton.	\$34.00 per ton.†	McNeal Pipe & Foundry Co., Burlington, N. J.
11	121*	70 tons special castings, .	2	\$57.00 per ton.	\$55.00 per ton.†	Camden Iron Works, Camden, N. J.

* Contract completed.

† Contract based upon this bid.

DURING THE YEAR 1899 — *Continued.**relating to the Dam and Aqueduct Department — Concluded.*

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1899.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1899.	
Sept. 8, '98,	June 15, '99,	-	- -	\$14,343 48	\$14,343 48	1
Mar. 23, '99,	June 15, '99,	Dec. 16, '99,	- -	19,739 48	19,739 48	2
Apr. 8, '99,	-	Dec. 30, '99,	Price of engine complete, \$6,200.	6,200 00	6,200 00	3
May 29, '99,	Sept. 1, '99,	Nov. 20, '99,	For superstructure complete, \$5,482.	5,499 54	5,499 54	4
June 19, '99,	Nov. 1, '99,	Jan. 6, '00,	Earth excavation, \$0.20 per cu. yd.; rock excavation, \$0.98 per cu. yd.; stone masonry, \$6.25 per cu. yd.	19,120 00	19,120 00	5
. . . . .	. . . . .	. . . . .	. . . . .	\$256,115 44	\$256,115 44	

Board relating to the Sudbury Department.

Apr. 27, '98,	Dec. 1, '97,	Feb. 24, '99,	- -	\$140,898 34	\$140,898 34	6
Apr. 27, '98,	Dec. 1, '97,	Feb. 23, '99,	- -	125,706 29	125,706 29	7
Oct. 29, '98,	Dec. 10, '98,	May 22, '99,	- -	2,350 06	2,350 06	8
May 17, '99,	Nov. 15, '99,	Dec. 23, '99,	Washed and screened sand deposited in filter-beds, \$0.60 per cu. yd.; earth excavation, \$0.21 per cu. yd.; Portland cement con- crete masonry, \$7.00 per cu. yd.	42,384 83	42,384 83	9
. . . . .	. . . . .	. . . . .	. . . . .	\$311,339 51	\$311,339 51	

*relating to the Distribution Department.***Water Pipes.**

July 13, '98,	Dec. 1, '98,	Mar. 8, '99,	- -	\$5,776 70	\$5,776 70	10
July 13, '98,	Dec. 1, '98,	July 31, '99,	- -	4,167 30	4,167 30	11

CONTRACTS MADE AND PENDING

*Contracts made by the Metropolitan Water Board***Water Pipes — Concluded.**

1. Number of Con- tract.	2. WORK.	3. Number of Bids.	AMOUNT OF BID.		6. Contractor.
			4. Next to Low- est.	5. Lowest.	
1	144* 1,425 tons cast-iron water pipes; 275 tons 30-inch, 370 tons 24-inch, 780 tons 20-inch, 25 tons special castings.	3	Items 1, 2 and 3, \$17.94 per ton; Item 4, \$37.00 per ton.	Items 1 and 2, \$17.68 per ton; Item 3, \$18.04 per ton; Item 4, \$36.00 per ton.†	McNeal Pipe & Foundry Co., Burlington, N. J.
2	156* 160 tons special castings, .	2	Item 1, \$45.00 per ton; Item 2, \$75.00 per ton.†	Item 1, \$44.00 per ton; Item 2, \$58.00 per ton.‡	Camden Iron Works, Camden, N. J.
3	172* 36 tons special castings, .	2	\$180.00 per ton.	\$98.00 per ton.†	Camden Iron Works, Camden, N. J.
4	Special order.* 21 tons 24, 16, 12, 8, 6 and 4 inch cast-iron pipes; 4.8 tons special castings.	2	16-inch pipe, \$22.50 per ton; 8-inch pipe, \$22.90 per ton; 4-inch pipe, \$23.90 per ton; Lot 1, \$45.00 per ton; Lot 2, \$75.00 per ton.	16, 8 and 4 inch pipe, \$22.40 per ton; Lot 1, \$50.00 per ton; Lot 2, \$55.00 per ton.†	Camden Iron Works, Camden, N. J.
5	Special order.* 95 tons 30-inch cast-iron water pipes.	3	\$22.00 per ton.	\$21.60 per ton.†	Camden Iron Works, Camden, N. J.
6	Special order.* 66 tons cast-iron water pipes; 48 tons 8-inch, 8 tons 6-inch, 10 tons 10-inch.	3	\$23.40 per ton.†	\$22.95 per ton.‡	United States Cast Iron Pipe & Foundry Co., Burlington, N. J.
7	Special order.* 100 tons 16-inch cast-iron water pipes.	3	\$25.00 per ton.	\$24.70 per ton.†	United States Cast Iron Pipe & Foundry Co., Burlington, N. J.
8	Special order.* 150 tons 60-inch cast-iron water pipes.	2	\$25.50 per ton.†	\$24.90 per ton.‡	Camden Iron Works, Camden, N. J.
9	Special order.* 70 pieces 6-inch and 20 pieces 8-inch cast-iron water pipes.	3	\$23.40 per ton.	\$28.00 per ton.†	Camden Iron Works, Camden, N. J.
	Total, . . . .	. . . .	. . . .	. . . .	. . . . .

* Contract completed.

† Contract based upon this bid.

‡ The lowest bidder did not comply with terms of delivery.

DURING THE YEAR 1899 — *Continued.**relating to the Distribution Department — Continued.***Water Pipes — Concluded.**

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1899.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1899.	
Feb. 15, '99,	June 1, '99,	June 22, '99,	30 and 24 inch pipe, \$17.68 per ton of 2,000 pounds; 20-inch pipe, \$18.04 per ton of 2,000 pounds; special castings, \$36.00 per ton of 2,000 pounds, delivered at the pipe yard.	\$27,149 83	\$27,149 83	1
Apr. 8, '99,	Aug. 1, '99,	Nov. 23, '99,	3-way and 4-way branches, blow-off branches without man-holes, curves, reducers, caps, offset pipes and sleeves, \$45.00 per ton of 2,000 pounds; manhole pipes, blow-off branches with manholes, flanged pipes and Y branches, \$75.00 per ton of 2,000 pounds, delivered at the pipe yard.	8,067 99	8,067 99	2
June 24, '99,	Jan. 1, '00,	Dec. 21, '99,	Suction, discharge and condenser pipes, \$98.00 per ton of 2,000 pounds, delivered at the pipe yard.	3,591 16	3,591 16	3
Mar. 25, '99,	-	June 6, '99,	Straight pipes, \$22.40 per ton of 2,000 pounds; 3-way branches, curves and caps, \$50.00 per ton of 2,000 pounds; over-flow pipes, special curves and tees, \$55.00 per ton of 2,000 pounds, delivered at Clinton, Mass.	763 17	763 17	4
Mar. 29, '99,	-	July 6, '99,	Straight pipe, \$21.60 per ton of 2,000 pounds, delivered at the pipe yard.	2,119 84	2,119 84	5
May 20, '99,	July 15, '99,	July 20, '99,	Straight pipe, \$23.40 per ton of 2,000 pounds; 38 tons delivered at Marlborough, 28 tons delivered at Glenwood.	1,551 35	1,551 35	6
July 20, '99,	-	Aug. 22, '99,	Straight pipe, \$24.70 per ton of 2,000 pounds, delivered at the pipe yard.	2,467 09	2,467 09	7
Aug. 7, '99,	Oct. 15, '99,	Nov. 23, '99,	Straight pipe, \$25.50 per ton of 2,000 pounds, delivered at the pipe yard.	3,833 39	3,833 39	8
Nov. 10, '99,	-	Dec. 9, '99,	Straight pipe, \$28.00 per ton of 2,000 pounds, delivered at the pipe yard.	595 24	595 24	9
. . .	. . .	. . .	. . . . .	\$60,072 56	\$60,072 56	

CONTRACTS MADE AND PENDING

*Contracts made by the Metropolitan Water Board***Pipe-laying.**

1. Num- ber of Con- tract.	2. WORK.	3. Num- ber of Bids.	AMOUNT OF BID.		6. Contractor.
			4. Next to Low- est.	5. Lowest.	
1	109* Laying 17,800 lin. ft. of 36-inch cast-iron water pipes in West Roxbury and Dorchester (Section 20).	11	\$26,717 00	\$23,819 00†	H. A. Hanscom & Co., West Medford, Mass.
2	183* Laying 19,200 lin. ft. of 16-inch cast-iron water pipes in Revere, Saugus and Lynn (Section 26).	10	11,477 00	11,166 00†	Mirick & Wentworth, Malden, Mass.
3	184* Laying 12,200 lin. ft. of 16-inch and 2,800 lin. ft. of 12-inch cast-iron water pipes in Lynn (Section 27).	4	10,811 50	9,742 50†	O'Rourke & Nelson, Boston, Mass.
4	155* Laying 3,200 lin. ft. of 24-inch and 9,100 lin. ft. of 20-inch cast-iron water pipes in Medford and Arlington (Section 28).	14	9,126 50†	8,247 50	Bruno & Salomone, Boston, Mass.
5	Agree- ment.* Laying 730 lin. ft. of 20-inch and 740 lin. ft. of 18-inch cast-iron water pipes in Medford and Arlington (Section 28).	3	1,507 25	1,483 00†	H. A. Hanscom & Co., West Medford, Mass.
	Total,				

Miscellaneous.

6	46 Pumping engine for the Chestnut Hill high-service pumping station in Boston.	-	-†	-†	The Edward P. Allis Co., Milwaukee, Wis.
7	72 3 pumping engines for the Chestnut Hill low-service pumping station in Boston.	5	\$195,000 00	\$136,500 00†	Holly Mfg. Co., Lockport, N. Y.
8	80* Addition to Chestnut Hill pumping station.	3	73,980 00	47,979 00†	C. A. Dodge & Co., Boston, Mass.
9	100* Steam piping for the Allis No. 4 engine, Chestnut Hill high-service pumping station, Boston.	6	1,745 00	1,569 00†	The William H. Garrison Co., Boston, Mass.
10	122 Pumping engine for the Spot Pond high-service pumping station in Stoneham, Mass.	4	64,000 00	62,500 00†	Holly Mfg. Co., Lockport, N. Y.
11	123* 8 36-inch, 2 12-inch sluice gates, steel beams and cast-iron floor plates at the Middlesex Fells Reservoir.	3	5,748 00	3,420 00†	Coffin Valve Co., Boston, Mass.

* Contract completed.

† Contract based upon this bid.

‡ Competitive bids were not received on this contract.

DURING THE YEAR 1899 — *Continued.**relating to the Distribution Department — Continued.***Pipe-laying.**

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1899.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1899.	
May 11, '98,	Sept. 15, '98,	Jan. 3, '99,	- -	\$30,673 90	\$30,673 90	1
Sept. 19, '98,	Dec. 1, '98,	July 15, '99,	- -	11,593 68	11,593 68	2
Sept. 19, '98,	Dec. 1, '98,	May 16, '99,	- -	11,200 66	11,200 66	3
April 8, '99,	July 1, '99,	Aug. 1, '99,	Laying 24-inch pipe, \$0.74 per lin. ft.; 20-inch pipe, \$0.67 per lin. ft.	9,435 26	9,435 26	4
Aug. 29, '99,	-	Dec. 13, '99,	Laying 20 and 16 inch pipe, \$0.70 per lin. ft.	1,618 89	1,618 89	5
. . .	. . .	. . .	. . . . .	\$64,522 89	\$64,522 89	

Miscellaneous.

Jan. 1, '97,	July 1, '98,	-	- -	\$114,000 00	\$114,000 00	6
Oct. 20, '97,	July 20, '99,	-	- -	186,500 00	100,000 00	7
Sept. 21, '97,	Mar. 1, '98,	Sept. 11, '99,	- -	48,694 62	48,694 62	8
Feb. 12, '98,	-	Mar. 20, '99,	- -	1,637 25	1,637 25	9
Sept. 20, '98,	Jan. 20, '00,	-	- -	62,500 00	30,000 00	10
Aug. 11, '98,	Dec. 1, '98,	Nov. 13, '99,	- -	3,420 00	3,420 00	11

CONTRACTS MADE AND PENDING

*Contracts made by the Metropolitan Water Board***Miscellaneous—Continued.**

1. Number of Con- tract.	2. WORK.	3. Num- ber of Bids.	AMOUNT OF BID.		6. Contractor.
			4. Next to Low- est.	5. Lowest.	
1	126 Low-service pumping station at Chestnut Hill Reservoir, Boston, Mass.	9	\$193,050 00	\$182,659 50†	Norcross Bros., Boston, Mass.
2	132* Sluice-gates at the low-service pumping station, Chestnut Hill Reservoir.	4	3,936 00	3,586 00†	The Atlantic Works, Boston, Mass.
3	136* Water-pipe boxes and siphon across the Saugus River between Saugus and Lynn.	5	4,890 00	4,584 00†	Wm. H. Ryan & Co., Boston, Mass.
4	137 High-service pumping station and gate-house at Spot Pond, Stoneham.	10	110,822 50	108,480 00†	McNeil Bros., Boston, Mass.
5	139* High-service reservoir and gate-chamber in the Middlesex Fells in Stoneham, Mass. (second letting).	3	56,688 50	54,871 50†	H. P. Nawn & N. S. Brock, Boston, Mass.
6	141 3 vertical fire-tube boilers at the Chestnut Hill low-service pumping station.	4	19,650 00†	19,050 00	The Atlantic Works, Boston, Mass.
7	142 American mechanical stokers on 2 90-inch Belpaire boilers at the Chestnut Hill high-service pumping station.	1	-†	2,960 00†	The American Stoker Co., New York, N. Y.
8	143 Hydraulic plunger elevator for Chestnut Hill low-service pumping station.	4	775 00	720 00†	Moore & Wyman Elevator & Machine Works, Boston, Mass.
9	145* 4 sluice gates at the northern high-service pumping station.	3	1,836 00	1,640 00†	The Atlantic Works, Boston, Mass.
10	146* 1 36-inch and 1 30-inch hydraulic-lift valves, 2 36-inch, 3 24-inch and 2 20-inch screw-lift valves.	3	4,370 00	4,059 00†	Coffin Valve Co., Boston, Mass.

* Contract completed.

† Contract based upon this bid.

‡ Competitive bids were not received on this contract.

DURING THE YEAR 1899 — *Continued.**relating to the Distribution Department — Continued.***Miscellaneous — Continued.**

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1899.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1899.	
Aug. 26, '98,	July 15, '99,	-	- -	\$197,600 00	\$180,000 00	1
Sept. 10, '98,	Jan. 1, '99,	July 20, '99,	- -	3,536 00	3,536 00	2
Apr. 8, '99,	June 15, '99,	Sept. 2, '99,	For whole work, \$4,584.00, .	4,778 61	4,778 61	3
Jan. 7, '99,	Dec. 15, '99,	-	Earth excavation, \$0.35 per cu. yd.; rock excavation, \$1.75 per cu. yd.; natural cement concrete masonry in foundations, \$5.00 per cu. yd.; Portland cement concrete masonry in foundations, \$6.50 per cu. yd.; concrete floors, \$1.00 per sq. yd.; brick masonry in foundations, \$11.00 per cu. yd.; granite-stone masonry in foundations, \$38.00 per cu. yd.; pumping station superstructure complete with all appurtenances, \$85,000.00; gate-house superstructure complete, \$2,600.00.	116,000 00	106,000 00	4
Nov. 4, '98,	July 1, '99,	Nov. 14, '99,	- -	68,836 40	68,836 40	5
Jan. 31, '99,	Oct. 1, '99,	-	\$6,550 per boiler, . . .	19,950 00	16,500 00	6
Jan. 23, '99,	-	-	For whole work, \$2,960.00, .	2,960 00	2,000 00	7
Jan. 14, '99,	-	-	For whole work, \$720.00, .	720 00	500 00	8
Feb. 23, '99,	Oct. 1, '99,	Oct. 9, '99,	\$410 per gate, . . .	1,640 00	1,640 00	9
Feb. 23, '99,	Aug. 1, '99,	Dec. 13, '99,	36-inch hydraulic-lift valve, \$960.00; 30-inch hydraulic-lift valves, \$800.00; 28-inch screw-lift valves, \$605.00; 24-inch screw-lift valves, \$233.00; 20-inch screw-lift valves, \$196.00.	4,059 00	4,059 00	10

CONTRACTS MADE AND PENDING

*Contracts made by the Metropolitan Water Board***Miscellaneous — Continued.**

1. Number of Con- tract.	2. WORK.	3. Num- ber of Bids.	AMOUNT OF BID.		6. Contractor.	
			4. Next to Low- est.	5. Lowest.		
1	148	2 hand travelling cranes, one at Chestnut Hill low- service pumping station, one at Spot Pond high- service pumping station.	4	\$5,594 00†	\$5,000 00	New England Structural Co., Boston, Mass.
2	158	3 vertical fire-tube boilers at the Spot Pond high- service pumping station.	3	24,600 00	22,050 00†	Lake Erie Boiler Works, Buffalo, N. Y.
3	159	Stable, shed and black- smith shop at Glenwood pipe yard, Medford, Mass.	11	24,000 00	22,800 00†	W. L. Clark & Co., Bos- ton, Mass.
4	163	Green's improved fuel economizers at the Chestnut Hill low-ser- vice pumping station and the Spot Pond high-ser- vice pumping station.	1	-†	-†	Fuel Economizer Co., Matteawan, N. Y.
5	165*	Drainage system at Spot Pond, Stoneham, Mass.	7	22,945 00	22,508 00†	O. E. Trumbull & Co., Boston, Mass.
6	167	Masonry core walls and earth embankments for dams at Spot Pond.	13	24,815 00	23,032 50†	Brodhead Contracting Co., Easton, Pa.
7	169	Furnishing and erecting a steam engine for electric light plant at Chestnut Hill low-service pump- ing station.	4	767 00	741 00†	Fitchburg Steam Engine Co., Fitchburg, Mass.

* Contract completed.

† Contract based upon this bid.

‡ Competitive bids were not received on this contract.

DURING THE YEAR 1899 — *Continued.**relating to the Distribution Department — Continued.***Miscellaneous — Continued.**

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1899.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1899.	
Mar. 31, '99,	Nov. 1, '99,	-	\$2,797 per crane, . . .	\$5,594 00	\$5,500 00	1
May 8, '99,	Dec. 1, '99,	-	\$7,350 per boiler, . . .	22,050 00	20,000 00	2
May 25, '99,	Nov. 15, '99,	-	For whole work, \$22,800.00,	22,800 00	20,300 00	3
May 10, '99,	Oct. 1, '99,	-	For whole work, \$3,286.00, .	3,286 00	3,000 00	4
June 8, '99,	Sept. 1, '99,	Oct. 31, '99,	Earth excavation for cast-iron and vitrified pipes and masonry conduit, \$0.60 per cu. yd.; earth excavation for open channel, \$0.50 per cu. yd.; borrowed earth, \$0.40 per cu. yd.; rock excavation, \$2.50 per cu. yd.; Portland cement concrete masonry, \$7.50 per cu. yd.; brick masonry laid in Portland cement, \$14.00 per cu. yd.; laying 30-inch cast-iron pipe, \$0.88 per lin. ft.; laying 24-inch, 20-inch and 12-inch cast-iron pipe, \$0.60 per lin. ft.; furnishing and laying 24-inch vitrified pipe, \$1.06 per lin. ft.; stone paving, \$1.00 per sq. yd.; spruce lumber placed in foundations, \$35.00 per M ft. B. M.	24,099 75	24,099 75	5
June 19, '99,	Oct. 1, '99,	-	Earth excavation, \$0.45 per cu. yd.; rock excavation, \$1.50 per cu. yd.; borrowed earth, \$0.30 per cu. yd.; American natural hydraulic cement concrete masonry, \$5.50 per cu. yd.; Portland cement concrete masonry, \$6.85 per cu. yd.; plastering of Portland cement, \$0.40 per sq. yd.	34,004 75	34,004 75	6
June 8, '99,	Oct. 1, '99,	-	For whole work, \$741.00, .	741 00	-	7

CONTRACTS MADE AND PENDING

*Contracts made by the Metropolitan Water Board***Miscellaneous — Continued.**

1. Number of Con- tract.	2. WORK.	3. Num- ber of Bids.	AMOUNT OF BID.		6. Contractor.	
			4. Next to Low- est.	5. Lowest.		
1	170	Furnishing and erecting an electric generator and switch-board for the Chestnut Hill low-service pumping station.	3	\$1,430 00	\$1,346 00†	Westinghouse Electric & Manufacturing Co., Pittsburg, Pa.
2	171	5 60-inch sluice gates with hydraulic lifts, 1 48-inch, 230-inch sluice gates with screw lifts at Chestnut Hill Reservoir, Spot Pond and Forbes Hill Reservoir.	3	10,639 00	8,986 00†	The Atlantic Works, Boston, Mass.
3	173	Gate-house at the northern high-service reservoir in the Middlesex Fells, Stoneham.	8	5,242 00†	4,900 00	W. L. Clark & Co., Boston, Mass.
4	174	Improvement of Spot Pond, Section 1.	13	39,700 00	36,256 00†	Newell & Snowling Construction Co., Uxbridge, Mass.
5	175	Improvement of Spot Pond, Section 2.	14	46,210 00	42,930 00†	Moulton & O'Mahoney, Boston, Mass.
6	177	Improvement of Spot Pond, Section 3.	7	46,308 00†	45,717 50	Newell & Snowling Construction Co., Uxbridge, Mass.
7	178	Gate-chamber and connections at Chestnut Hill Reservoir.	9	21,481 00	19,657 50†	Baker & Judson, Gloversville, N. Y.

† Contract based upon this bid.

DURING THE YEAR 1899—*Continued.**relating to the Distribution Department—Continued.***Miscellaneous—Continued.**

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1899.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1899.	
June 10, '99,	Oct. 16, '99,	-	For whole work, \$1,846.00, .	\$1,846 00	\$1,000 00	1
June 23, '99,	Jan. 1, '00,	-	60-inch sluice gates with hydraulic lifts erected at Chestnut Hill Reservoir, \$1,436.00 per gate; 60-inch sluice gates with hydraulic lifts erected at Spot Pond, \$1,610.00 per gate; 48-inch sluice gates with screw lifts erected at Chestnut Hill Reservoir, \$993.00 per gate; 30-inch sluice gates with screw lifts erected at Spot Pond, \$417 per gate; 30-inch sluice gates with screw lifts delivered on cars in Boston, \$324 per gate.	9,262 00	8,000 00	2
July 18, '99,	Nov. 1, '99,	-	For whole work, \$5,242.00, .	5,242 00	5,000 00	3
July 19, '99,	Dec. 15, '99,	-	Earth excavation, \$0.26 per cu. yd.; rock excavation, \$1.50 per cu. yd.; riprapping slopes, \$0.98 per cu. yd.	45,737 77	41,600 00	4
July 19, '99,	July 15, '99,	-	Earth excavation, \$0.17½ per cu. yd.; rock excavation, \$3.00 per cu. yd.; riprapping slopes, \$1.50 per cu. yd.	42,930 00	38,300 00	5
Aug. 8, '99,	July 15, '00,	-	Earth excavation, \$0.18½ per cu. yd.; rock excavation, \$1.50 per cu. yd.; riprapping slopes, \$1.98 per cu. yd.	46,308 00	14,500 00	6
Aug. 7, '99,	Dec. 1, '99,	-	Building and maintaining coffer-dam, etc., \$3,000.00; earth excavation, \$0.75 per cu. yd.; rock excavation, \$3.00 per cu. yd.; laying 60.5-inch cast-iron pipe, \$2.50 per lin. ft.; laying 48-inch cast-iron pipe, \$1.80 per lin. ft.; laying 12-inch cast-iron pipe, \$0.50 per lin. ft.; chambers for blow-off valves, \$60.00 per chamber; concrete masonry made with Portland cement mortar, \$8.00 per cu. yd.; ashlar masonry laid in mortar, \$15.00 per cu. yd.; dimension stone masonry laid in mortar, \$30.00 per cu. yd.	19,657 50	17,000 00	7

CONTRACTS MADE AND PENDING

*Contracts made by the Metropolitan Water Board***Miscellaneous — Concluded.**

1. Number of Con- tract.	2. WORK.	3. Num- ber of Bids.	AMOUNT OF BID.		6. Contractor.
			4. Next to Low- est.	5. Lowest.	
1	179 Improvement of Spot Pond, Section 4.	6	\$78,680 00†	\$76,530 00	Moulton & O'Mahoney, Boston, Mass.
2	180 Improvement of Spot Pond, Section 6.	12	44,845 00†	42,364 00	P. H. Fitzgerald, New London, Conn.
3	181 Cast-iron floor plates, steel beams and cast-iron stop-plank grooves at Chestnut Hill Reservoir and Spot Pond.	3	4,825 00	3,680 00†	Coffin Valve Co., Boston, Mass.
4	Special order.* Surface condenser, . . .	-	-†	-†	Wheeler Condenser & Engineering Co., New York, N. Y.
5	Special order.* 4 16-inch valves, . . .	-	-†	-†	Coffin Valve Co., Boston, Mass.
6	Special order. Cast-iron floor plates in Chestnut Hill and Spot Pond pumping stations.	3	1,101 00	1,090 00†	Chelmsford Foundry Co., Boston, Mass.
7	Special order.* 6 12-inch valves, . . .	-	-†	-†	Coffin Valve Co., Boston, Mass.
8	Special order. 1 36-inch sluice gate, . . .	-	-†	-†	The Atlantic Works, Boston, Mass.
9	Special order. 2 60-inch sluice gates at Spot Pond.	2	1,864 00	1,482 00†	Coffin Valve Co., Boston, Mass.
	Total miscellaneous, . . .	. . .	. . .	. . .	. . . . .
	Total for Distribution Department.	. . .	. . .	. . .	. . . . .

* Contract completed.

† Contract based upon this bid.

‡ Competitive bids were not received on this contract.

DURING THE YEAR 1899—*Continued.**relating to the Distribution Department—Concluded.***Miscellaneous—Concluded.**

7. Date of Contract.	8. Date for Completion of Contract.	9. Date of Final Estimate.	10. Prices of Principal Items of Contracts made in 1899.	11. Amount of Contract.	12. Value of Work done Dec. 31, 1899.	
Aug. 8, '99,	July 15, '00,	-	Earth excavation, \$0.27 per cu. yd.; rock excavation, \$3.00 per cu. yd.; riprapping slopes, \$2.00 per cu. yd.	\$78,630 00	\$21,200 00	1
Aug. 24, '99,	Dec. 15, '99,	-	Taking down and removing masonry walls of buildings and reservoirs, \$1.00 per cu. yd.; earth excavation, \$0.38 per cu. yd.; rock excavation, \$1.50 per cu. yd.; riprapping slopes, \$1.00 per cu. yd.; natural cement concrete masonry, \$5.10 per cu. yd.; Portland cement concrete masonry, \$8.15 per cu. yd.; plastering of Portland cement, \$0.24 per sq. yd.; dimension stone masonry laid in mortar, \$25.00 per cu. yd.; laying 60-inch cast-iron pipe, \$1.25 per lin. ft.	44,345 00	37,400 00	2
Aug. 17, '99,	Dec. 1, '99,	-	For whole work, \$3,680.00, .	3,680 00	2,500 00	3
Apr. 10, '99,	-	July 20, '99,	For whole work, \$725.00, .	725 00	725 00	4
May 29, '99,	-	Aug. 10, '99,	\$162.00 per valve, . . .	648 00	648 00	5
Aug. 5, '99,	-	-	For whole work, \$1,090.00, .	1,090 00	275 00	6
Sept. 11, '99,	-	Dec. 9, '99,	\$136.00 per valve, . . .	816 00	816 00	7
Oct. 4, '99,	-	-	\$430.00 per gate, . . .	430 00	100 00	8
Oct. 20, '99,	-	-	\$716.00 per gate, . . .	1,432 00	1,200 00	9
. . .	. . .	. . .	. . . . .	\$1,201,686 65	\$981,770 88	
. . .	. . .	. . .	. . . . .	\$1,826,281 60	\$1,106,365 33	

CONTRACTS MADE AND PENDING DURING THE YEAR 1899 — *Concluded.*

Summary of Contracts.

	Approximate Amount of Contracts.	Value of Work done Decem- ber 31, 1899.
Wachusett Reservoir, 12 contracts,	\$1,727,584 90	\$373,915 31
Wachusett Aqueduct and Clinton sewerage, 6 contracts,	236,995 44	236,995 44
Wachusett Dam (preliminary work), 1 contract,	19,120 00	19,120 00
Sudbury department, 4 contracts,	311,339 51	311,339 51
Distribution department, 43 contracts,	1,308,192 13	1,089,652 86
Total of 66 contracts made and pending during the year 1899,	\$3,603,181 98	\$2,031,023 12
127 contracts completed in 1896, 1897 and 1898,	5,099,884 22	5,099,884 22
	\$8,703,066 20	\$7,130,907 34
Deduct for work done on 11 Sudbury Reservoir contracts by the city of Boston,	512,000 00	512,000 00
Total of 193 contracts,	\$8,191,066 20	\$6,618,907 34

APPENDIX No. 2.

TESTS OF CEMENT MADE AT THE OFFICE OF THE METROPOLITAN WATER
BOARD, DAM AND AQUEDUCT DEPARTMENT, CLINTON, MASS.

The methods of testing were the same as described in Appendix No. 3, of the annual report of the Metropolitan Water Board for the year 1897. The tests are largely of cements used in 1896 and 1897 for the construction of the Wachusett Aqueduct, but the results of tests of cements used in 1898 and 1899 are also included in the tables which follow.

Tabulation of Cement Tests for All Brands of Natural Cement, of which Nine Hundred Barrels or More were used on Construction Work by the Dam and Aqueduct and Reservoir Departments in 1896, 1897, 1898 and 1899.

BRAND.	Number of Barrels used.	Composition of Briquette.	FINENESS.			WIRE TESTS.		TENSILE STRENGTH.					
			Per Cent. Residue on No. 60 Sieve, Square Inch.	Per Cent. Residue on No. 100 Sieve, Square Inch.	Per Cent. Residue on No. 180 Sieve, Square Inch.	Minutes to bear Light Wire.	Minutes to bear Heavy Wire.	ONE DAY.		SEVEN DAYS.		TWENTY-EIGHT DAYS.	
								Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.
Beach,	8,380	{ Neat, . 1 to 1, .	7.5	20.6	-	42	76	892	123	684	136	64	223
Hoffman,	45,321	{ Neat, . 1 to 1, .	5.8	17.0	-	31	61	4,584	119	636	103	64	168
Norton,	60,877	{ Neat, . 1 to 1, .	-	-	-	29	52	-	-	2,989	132	132	210
Union,	900	{ Neat, . 1 to 1, .	8.1	22.4	-	38	89	6,244	115	2,924	105	156	198
		{ Neat, . 1 to 1, .	-	-	-	35	76	-	-	1,979	128	90	202
		{ Neat, . 1 to 1, .	1.3	9.9	18.1	10	26	183	164	1,967	96	70	150
		{ Neat, . 1 to 1, .	-	-	-	10	20	-	-	103	167	137	187
		{ Neat, . 1 to 1, .	-	-	-	-	-	-	-	153	156	36	206
Total,	115,478	{ Neat, . 1 to 1, .	7.1	20.0	-	35	76	11,903	118	5,745	132	423	203
		{ Neat, . 1 to 1, .	-	-	-	32	63	-	-	5,680	103	326	182

Tabulation of Cement Tests for All Brands of Natural Cement, etc. — Concluded.

BRAND.	Number of Barrels used.	Composition of Briquette.	TENSILE STRENGTH — Concluded.											
			THREE MONTHS.		SIX MONTHS.		ONE YEAR.		EIGHTEEN MONTHS.		TWO YEARS.		THREE YEARS.	
			Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.	Number of Briquettes.	Pounds per Square Inch.
Beach,	8,380	{ Neat, . 1 to 1, .	64	348	62	389	64	430	14	485	64	467	—	—
Hoffman,	45,321	{ Neat, . 1 to 1, .	107	343	101	392	91	453	6	468	91	468	17	534
Norton,	60,877	{ Neat, . 1 to 1, .	70	352	60	390	70	463	—	—	60	440	—	—
Union,	900	{ Neat, . 1 to 1, .	67	273	27	317	62	411	12	393	22	409	—	—
Total,	115,478	{ Neat, . 1 to 1, .	308	331	250	383	287	420	32	447	237	455	17	534
			307	312	260	343	290	365	32	411	237	339	17	351

Tabulation of Cement Tests for All Brands of Portland Cement, of which Nine Hundred Barrels or More were used on Construction Work by the Dam and Aqueduct and Reservoir Departments in 1896, 1897, 1898 and 1899.

BRAND.	Number of Barrels used.	Composition of Briquette.	FINENESS.			WIRE TESTS.		TENSILE STRENGTH.					
			Per Cent. Residue on No. 50 Sieve, Square Inch.	Per Cent. Residue on No. 100 Sieve, Square Inch.	Per Cent. Residue on No. 180 Sieve, Square Inch.	Minutes to bear Light Wire.	Minutes to bear Heavy Wire.	ONE DAY.		SEVEN DAYS.		TWENTY-EIGHT DAYS.	
								Number of Briquettes.	Square Inch.	Number of Briquettes.	Square Inch.	Number of Briquettes.	Square Inch.
Atlas,	18,507	{ Neat, . 2 to 1, .	.4	10.0	24.7	88	425	1,026	399	968	686	115	739
Brooks-Shoobridge,	5,706	{ Neat, . 2 to 1, .	1.0	11.5	26.1	82	295	506	211	1,014	319	115	322
Giant,	15,394	{ Neat, . 2 to 1, .	1.0	9.9	21.9	22	125	1,575	293	682	452	55	452
Iron Clad,	7,723	{ Neat, . 2 to 1, .	.3	9.0	26.0	70	230	824	434	408	571	45	619
Jeffettin-Giriatow,	979	{ Neat, . 2 to 1, .	2.8	17.9	30.9	130	444	145	283	145	570	54	596
West Kent,	3,394	{ Neat, . 2 to 1, .	1.7	18.6	31.1	5	88	449	178	449	356	59	456
Total,	51,708	{ Neat, . 2 to 1, .	.8	10.7	24.7	60	269	5,425	335	3,272	530	398	584
							114	3,281		292		403	327

APPENDIX No. 3.

TABLE No. 1. — *Monthly Rainfall in Inches at Various Places on the Metropolitan Water Works, in 1899.*

PLACE.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
Princeton,	2.76	4.96	6.66	1.74	1.41	4.81	3.70	2.67	4.15	2.80	1.85	2.21	39.60
Jefferson,	2.92	5.06	6.90	2.13	1.28	7.37	4.82	3.40	3.84	2.84	1.98	2.12	44.63
Sterling,	2.78	5.26	6.71	1.80	0.99	4.39	3.43	3.54	3.82	2.59	1.85	1.70	38.86
South Clinton,	3.27	5.18	6.83	2.08	1.64	5.49	3.33	3.18	4.63	2.65	2.12	2.10	42.50
Sudbury Dam,	4.05	4.81	6.56	1.95	1.41	2.40	2.94	1.26	3.75	2.53	2.10	1.70	35.46
Framingham,	4.19	4.79	7.05	1.73	1.38	2.48	3.16	1.59	3.78	2.61	2.12	1.71	36.59
Ashland Dam,	4.29	4.99	7.15	1.82	1.72	2.34	3.17	1.49	4.13	2.84	1.96	1.69	37.59
Jordaville,	4.18	5.04	7.27	2.10	1.29	2.81	3.60	1.39	4.12	2.79	2.54	2.03	39.16
Lake Cochituate,	4.36	4.44	7.31	1.70	1.06	2.79	3.20	2.17	4.65	3.05	2.31	1.92	38.96
Chestnut Hill Reservoir,	4.51	5.01	7.05	1.47	0.91	2.73	3.70	3.81	5.38	3.05	2.59	1.75	41.96
Spot Pond,	4.10	5.27	7.17	1.40	1.03	2.90	2.67	3.22	4.81	2.76	2.49	1.42	39.24
Average,	3.77	4.98	6.96	1.81	1.28	3.68	3.43	2.62	4.28	2.77	2.17	1.85	39.50

TABLE NO. 2. — *Rainfall in Inches at Jefferson, Mass., in 1899.*

DAY OF MONTH.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1,	-	-	-	-	*	-	-	-	*	-	0.28†	-
2,	-	-	*	-	0.60†	-	-	-	1.28†	-	-	0.25†
3,	-	*	0.54†	-	-	-	-	-	0.08†	-	*	-
4,	0.02†	0.80†	*	-	-	-	-	-	0.09†	-	0.59†	0.05§
5,	-	0.05†	0.75†	-	-	-	*	-	-	-	-	-
6,	*	*	-	-	-	-	0.13†	-	0.05†	0.19†	-	-
7,	0.97||	*	0.85†	*	-	-	-	-	-	-	-	-
8,	-	0.95†	-	0.98†	-	1.31†	*	-	-	-	-	0.03†
9,	0.03†	-	0.08†	-	-	-	2.85†	-	-	0.18†	-	-
10,	-	-	-	-	-	-	-	*	-	-	-	-
11,	-	-	-	-	0.25†	-	-	1.00†	-	-	*	0.02†
12,	-	*	0.19†	0.13†	-	-	0.13†	-	0.09†	-	0.85||	0.34†
13,	*	*	-	-	0.09†	-	-	-	-	-	-	-
14,	0.35†	2.60†	*	-	-	-	-	-	-	-	*	-
15,	-	-	*	-	-	0.51†	0.28†	-	-	-	0.13§	0.35§
16,	*	*	0.85§	0.76†	*	1.51†	-	-	-	-	-	-
17,	0.72†	0.15†	-	-	0.17†	-	-	-	-	*	-	0.07§
18,	-	0.22†	*	-	*	-	-	-	-	1.18†	-	-
19,	-	-	1.40§	-	*	-	-	-	-	-	0.05†	0.36†
20,	-	-	-	-	0.08†	2.30†	-	-	1.48†	0.08†	-	-
21,	-	0.03†	-	0.17†	-	-	-	0.08†	0.60†	-	-	-
22,	-	-	*	-	-	-	-	2.29†	-	-	0.03†	-
23,	-	-	1.00†	-	-	-	-	-	-	0.05†	-	-
24,	*	-	-	0.09†	-	0.42†	-	0.03†	-	-	-	0.65§
25,	0.76§	-	-	-	-	0.27†	*	-	-	-	-	-
26,	-	*	0.46†	-	-	-	1.25†	-	0.09†	-	-	-
27,	-	0.28§	-	-	-	-	0.53†	-	-	-	-	-
28,	-	-	*	-	*	*	-	-	-	*	-	-
29,	-	-	0.60†	-	0.09†	1.05†	-	-	*	0.31†	-	-
30,	-	-	-	-	-	-	0.15†	-	0.08†	-	-	-
31,	0.07†	-	0.18†	-	-	-	-	-	-	0.85†	-	-
Totals,	2.92	5.08	6.90	2.13	1.28	7.37	4.82	3.40	3.84	2.84	1.93	2.12

Total for the year, 44.63 inches.

* Rainfall included in that of following day.

† Rain.

‡ Snow.

§ Rain and snow.

|| Rain, snow and hail.

¶ Snow and hail.

TABLE No. 3.—*Rainfall in Inches at Framingham, Mass., in 1899.*

DAY OF MONTH.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1,	0.12†	-	-	-	0.42†	-	-	-	*	-	0.08†	-
2,	-	-	*	-	0.23†	0.02†	-	-	0.73†	-	-	0.05†
3,	-	*	0.58†	-	-	-	-	-	0.08†	-	*	-
4,	0.01†	0.72§	*	-	-	-	-	-	-	-	0.70†	0.02†
5,	-	0.06†	0.88†	-	-	-	-	0.01†	-	-	-	-
6,	*	-	-	-	-	-	0.09†	-	-	0.42†	-	-
7,	1.04§	*	0.70†	*	-	0.09†	-	-	-	-	-	-
8,	-	0.97†	-	0.84†	-	-	1.23†	-	0.01†	-	-	0.01†
9,	0.02†	-	0.04†	-	-	-	*	-	-	0.31†	-	-
10,	-	-	-	-	-	-	0.20†	*	-	-	-	-
11,	-	-	0.01†	-	0.16†	-	-	*	*	-	*	0.01†
12,	-	*	0.09†	0.13†	-	-	0.02†	0.96†	0.14†	-	1.10§	0.30†
13,	*	*	-	-	0.12†	-	-	-	-	-	-	-
14,	0.50†	1.96†	*	0.01†	-	-	-	-	-	-	0.02†	-
15,	-	-	0.99§	-	-	*	-	-	-	-	0.05†	0.60†
16,	*	*	-	*	0.11†	0.79†	0.07†	-	-	-	-	-
17,	0.81†	0.38§	-	0.63§	-	-	0.01†	-	-	0.05†	-	*
18,	-	*	*	-	0.02†	-	-	-	-	0.23†	-	0.05†
19,	-	0.49†	1.69§	-	0.01†	-	-	-	-	-	0.12†	0.32†
20,	-	-	-	-	*	0.38†	-	-	1.84†	0.17†	-	-
21,	-	-	-	0.07†	0.24†	-	-	-	0.57†	-	-	-
22,	-	-	*	-	-	-	-	0.56†	-	-	0.05†	-
23,	-	-	1.42§	-	-	-	-	-	-	0.12†	-	-
24,	*	-	-	-	-	0.18†	-	0.02†	-	-	-	0.35§
25,	1.49§	-	-	0.04†	-	0.06†	*	0.02†	-	-	-	-
26,	-	*	0.28†	0.01†	-	-	1.11†	-	0.05†	-	-	-
27,	-	0.21†	-	-	-	-	0.31†	-	-	*	-	-
28,	-	-	*	-	0.02†	*	-	-	-	0.06†	-	-
29,	-	-	0.26†	-	0.05†	0.96†	*	-	*	0.16†	-	-
30,	-	-	*	-	-	-	0.12†	0.02†	0.36†	-	-	-
31,	0.20†	-	0.11†	-	-	-	-	-	-	1.09†	-	-
Totals,	4.19	4.79	7.05	1.73	1.38	2.48	3.16	1.59	3.78	2.61	2.12	1.71

Total for the year, 36.59 inches.

* Rainfall included in that of following day.

† Rain.

‡ Snow.

§ Rain and snow.

TABLE No. 4. — *Rainfall at Chestnut Hill Reservoir in 1899.*

DATE.	Inches.	Rain or Snow.	Duration.	DATE.	Inches.	Rain or Snow.	Duration.
Jan. 1,	0.10	Snow.	7.00 A.M. to 11.30 A.M.	Mar. 9,	0.02	Snow.	4.30 P.M. to 9.00 P.M.
Jan. 6,	1.06	Snow and rain.	5.30 A.M. to	Mar. 12,	0.05	Rain.	3.15 P.M. to 3.40 P.M.
Jan. 7,			2.00 A.M.	Mar. 15,	0.89	Rain.	4.15 P.M. to 11.45 P.M.
Jan. 13,	0.45	Rain.	4.45 P.M. to	Mar. 18,	1.74	Snow and	7.20 A.M.
Jan. 14,			5.30 P.M.	Mar. 19,			to
Jan. 16,	0.95	Rain.	6.30 P.M. to	Mar. 20,	1.40	Rain.	4.15 A.M.
Jan. 17,			5.00 A.M.	Mar. 22,			6.40 A.M. to
Jan. 24,	1.85	Rain and snow.	2.30 P.M. to	Mar. 23,	0.25	Snow.	8.00 P.M.
Jan. 25,			7.45 A.M.	Mar. 26,			5.30 A.M. to 1.10 P.M.
Jan. 31,	0.10	Snow.	9.00 P.M. to 2.00 A.M. Feb. 1.	Mar. 28,	0.39	Rain.	5.45 P.M. to
Total,	4.51			Mar. 29,			7.10 A.M.
Feb. 3,	0.78	Snow and rain.	11.30 A.M. to	Mar. 31,	0.11	Snow.	12.45 A.M. to 9.30 A.M.
Feb. 4,			8.45 A.M.	Total,	7.05		
Feb. 5,	0.05	Snow.	11.30 A.M. to 5.15 P.M.	Apr. 7,	0.78	Rain.	7.15 P.M. to
Feb. 6,	1.21	Snow.	11.00 P.M.	Apr. 8,			9.30 A.M.
Feb. 7,			to	Apr. 12,	0.10	Rain.	3.00 P.M. to 6.30 P.M.
Feb. 8,	1.89	Snow.	6.30 P.M.	Apr. 14,	0.03	Rain.	1.15 A.M. to 4.00 A.M.
Feb. 12,			6.45 A.M.	Apr. 16,	0.51	Rain and snow.	11.00 A.M. to
Feb. 13,	0.32	Rain and snow.	to 3.00 A.M.	Apr. 17,			12.30 A.M.
Feb. 14,			7.30 P.M. to	Apr. 20,	0.03	Rain.	6.45 P.M. to 7.45 P.M.
Feb. 16,	0.03	Rain.	4.30 A.M.	Apr. 24,	0.02	Rain.	7.00 P.M. to 8.00 P.M.
Feb. 17,			7.30 P.M. to 10.30 P.M.	Total,	1.47		
Feb. 18,	0.50	Rain and snow.	7.00 P.M. to 11.15 P.M.	May 1,	0.32	Rain.	7.30 P.M. to 11.30 P.M.
Feb. 26,	0.23	Rain.	8.30 P.M. to	May 8,	0.03	Rain.	9.00 P.M. to 10.00 P.M.
Feb. 27,			3.30 P.M.	May 11,	0.06	Rain.	4.00 P.M. to 5.30 P.M.
Total,	5.01			May 13,	0.16	Rain.	5.15 P.M. to 9.45 P.M.
Mar. 2,	0.72	Snow.	2.10 P.M. to	May 17,	0.05	Rain.	12.30 A.M. to 1.30 A.M.
Mar. 3,			3.00 A.M.	May 18,	0.06	Rain.	7.00 P.M. to 10.15 P.M.
Mar. 3,	0.63	Rain.	5.45 P.M.	May 21,	0.20	Rain.	2.00 P.M. to 10.00 P.M.
Mar. 4,			to	May 28,	0.03	Rain.	11.30 P.M. to 11.45 P.M.
Mar. 5,	0.08	Rain.	12.30 P.M.	Total,	0.91		
Mar. 5,			2.45 P.M. to 8.00 P.M.	June 2,	0.02	Rain.	8.40 A.M. to 9.30 A.M.
Mar. 7,	0.69	Snow and rain.	5.45 A.M. to 11.30 A.M.	June 7,	0.43	Rain.	5.10 P.M. to 9.45 P.M.
Mar. 7,	0.03	Snow.	7.00 P.M. to 11.45 P.M.	June 14,	0.01	Rain.	4.15 P.M. to 4.45 P.M.

TABLE No. 4. — *Rainfall at Chestnut Hill Reservoir in 1899* — Concluded.

DATE.	Inches.	Rain or Snow.	Duration.	DATE.	Inches.	Rain or Snow.	Duration.
June 15,	0.46	Rain.	4.45 P.M. to 9.45 P.M.	Sept. 11,	0.24	Rain.	4.20 P.M. to
June 20,	0.44	Rain.	5.45 P.M. to 8.30 P.M.	Sept. 12,			9.00 A.M.
June 24,	0.15	Rain.	4.10 P.M. to	Sept. 20,	3.34	Rain.	3.50 A.M. to 11.30 A.M.
June 25,			2.30 A.M.	Sept. 21,	0.14	Rain.	1.15 P.M. to 4.30 P.M.
June 25,	0.12	Rain.	10.45 A.M. to 3.30 P.M.	Sept. 26,	0.18	Rain.	1.30 A.M. to 4.30 A.M.
June 28,	1.10	Rain.	1.30 P.M. to	Sept. 26,	0.04	Rain.	1.00 P.M. to 3.00 P.M.
June 29,			6.30 A.M.	Sept. 29,	0.88	Rain.	8.40 P.M. to
Total,	2.73			Sept. 30,			12.15 A.M.
July 6,	0.11	Rain.	1.05 P.M. to 2.00 P.M.	Total,	5.38		
July 8,	0.53	Rain.	12.15 P.M. to 3.10 P.M.	Oct. 6,	0.57	Rain.	8.10 A.M. to 10.00 P.M.
July 8,	0.59	Rain.	5.15 P.M. to	Oct. 9,	0.31	Rain.	4.30 A.M. to 6.30 P.M.
July 9,			4.30 A.M.	Oct. 18,	0.61	Rain.	9.40 A.M. to 3.00 P.M.
July 9,	0.27	Rain.	3.15 P.M. to 4.20 P.M.	Oct. 20,	0.14	Rain.	6.45 A.M. to 2.00 P.M.
July 10,			4.00 A.M. to 7.10 A.M.	Oct. 23,	0.04	Rain.	6.00 A.M. to 10.30 A.M.
July 16,	0.10	Rain.	9.30 A.M. to 4.00 P.M.	Oct. 28,	0.07	Rain.	5.00 A.M. to 10.30 A.M.
July 25,	0.16	Rain.	8.15 A.M. to 2.15 P.M.	Oct. 29,	0.22	Rain.	12.30 P.M. to 7.00 P.M.
July 26,	0.89	Rain.	3.00 A.M. to 7.10 A.M.	Oct. 31,	1.09	Rain.	3.40 P.M. to 7.00 A.M.
July 26,	0.70	Rain.	9.00 A.M. to 1.15 P.M.	Total,	3.05		Nov. 1.
July 27,	0.29	Rain.	5.10 P.M. to 6.00 P.M.	Nov. 1,	0.52	Rain.	7.00 A.M. to 11.30 A.M.
July 30,	0.06	Rain.	6.15 A.M. to 8.00 A.M.	Nov. 3,	0.87	Rain.	10.00 P.M. to
Total,	3.70			Nov. 4,			6.45 A.M.
Aug. 4,	0.04	Rain.	5.00 A.M. to 6.00 A.M.	Nov. 11,	0.99	Rain and snow.	10.45 A.M. to
Aug. 10,	1.13	Rain.	11.15 A.M. to	Nov. 12,			7.45 A.M.
Aug. 11,			5.30 P.M.	Nov. 14,	0.02	Snow.	8.45 P.M. to 11.00 P.M.
Aug. 22,	0.04	Rain.	6.35 A.M. to 6.55 A.M.	Nov. 15,	0.02	Rain.	1.30 P.M. to 7.00 P.M.
Aug. 22,	2.37	Rain.	5.50 P.M. to 7.15 P.M.	Nov. 19,	0.11	Rain.	1.30 P.M. to 3.00 P.M.
Aug. 23,			5.15 A.M. to 5.45 A.M.	Nov. 22,	0.06	Rain.	6.15 A.M. to 2.30 P.M.
Aug. 24,	0.18	Rain.	1.00 A.M. to 6.40 A.M.	Total,	2.59		
Aug. 24,	0.10	Rain.	5.15 P.M. to	Dec. 2,	0.05	Rain.	6.00 A.M. to 8.30 A.M.
Aug. 25,			6.45 A.M.	Dec. 12,	0.22	Rain.	12.50 P.M. to 3.45 P.M.
Total,	3.81			Dec. 15,	0.70	Rain.	3.45 A.M. to 11.15 A.M.
Sept. 1,	0.52	Rain.	9.15 P.M. to	Dec. 18,	0.08	Rain.	1.30 A.M. to 3.00 A.M.
Sept. 2,			10.30 A.M.	Dec. 19,	0.33	Rain.	2.10 P.M. to 10.00 P.M.
Sept. 2,	0.04	Rain.	3.30 P.M. to 4.50 P.M.	Dec. 24,	0.37	Rain.	12.30 P.M. to 10.30 P.M.
Sept. 3,	0.07	Rain.	7.20 P.M. to 10.30 P.M.	Total,	1.75		
Sept. 7,	0.03	Rain.	10.30 P.M. to 11.15 P.M.				

Total rainfall for year, 41.96 inches.

TABLE NO. 5. — *Rainfall, in Inches, on the Sudbury Watershed,* 1875 to 1899.*

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals.
1875.	2.42	3.15	3.74	3.23	3.56	6.24	3.57	5.53	3.43	4.85	4.83	0.94	45.49
1876.	1.83	4.21	7.43	4.20	2.76	2.04	9.13	1.72	4.62	2.24	5.76	3.62	49.56
1877.	3.22	0.74	3.36	3.43	3.70	2.43	2.95	3.68	0.32	8.52	6.80	0.87	44.02
1878.	5.63	5.97	4.69	6.79	0.96	3.88	2.97	6.94	1.29	6.42	7.02	6.37	57.93
1879.	2.48	3.56	5.14	4.72	1.68	3.79	3.93	6.51	1.88	0.81	2.68	4.34	41.42
1880.	3.57	3.98	3.31	3.11	1.84	2.14	6.27	4.01	1.00	3.74	1.78	2.83	38.18
1881.	5.56	4.95	6.73	2.00	3.51	5.39	2.35	1.36	2.62	2.95	4.09	3.93	44.17
1882.	6.96	4.56	2.65	1.82	6.07	1.66	1.77	1.67	8.74	2.07	1.15	2.30	39.40
1883.	2.81	3.87	1.78	1.84	4.19	2.40	2.68	0.73	1.52	5.60	1.81	3.56	32.78
1884.	5.09	6.54	4.72	4.41	3.47	3.44	3.67	4.65	0.85	2.48	2.65	5.17	47.14
1885.	4.71	3.87	1.07	3.60	3.48	2.87	1.43	7.18	1.43	5.09	6.09	2.72	43.54
1886.	6.36	6.28	3.61	2.22	3.00	1.47	3.27	4.10	2.90	3.24	4.64	4.97	46.06
1887.	5.20	4.78	4.90	4.27	1.16	2.65	3.76	6.22	1.32	2.83	2.67	3.88	42.70
1888.	4.15	3.68	6.02	2.43	4.82	2.54	1.41	4.18	8.59	4.99	7.22	5.40	57.47
1889.	6.37	1.65	2.37	3.41	2.95	2.80	8.94	4.73	4.00	4.25	6.29	3.14	49.95
1890.	2.53	3.51	7.73	2.64	5.21	2.03	2.46	3.87	6.00	10.51	1.20	5.31	53.00
1891.	7.02	5.23	6.48	3.91	2.01	3.77	3.39	4.73	2.38	3.83	3.09	3.68	49.52
1892.	5.85	3.14	4.06	0.83	6.58	2.76	4.23	4.44	2.84	1.17	6.80	1.13	41.83
1893.	2.92	8.20	3.67	3.60	6.61	2.38	2.57	5.41	1.74	4.07	2.20	4.86	48.23
1894.	4.09	3.91	1.43	3.42	4.24	1.15	3.26	2.03	2.63	5.84	3.43	4.81	39.74
1895.	4.06	1.39	2.98	6.25	2.02	2.77	5.04	4.15	2.80	10.68	6.63	3.35	50.62
1896.	2.39	7.18	5.24	1.57	2.57	3.22	2.51	2.40	7.72	3.76	3.02	2.12	43.70
1897.	4.00	2.91	3.66	2.82	4.37	4.46	5.44	3.51	2.94	0.47	6.40	5.21	46.19
1898.	6.53	4.49	2.40	4.66	3.22	2.48	4.09	8.17	2.62	6.71	6.93	3.28	55.88
1899.	4.18	4.91	7.01	1.90	1.45	2.51	3.22	1.43	3.95	2.69	2.18	1.78	37.21
Totals.	108.22	106.35	110.18	81.08	83.33	73.27	94.31	103.90	80.83	109.31	105.36	89.59	1,145.73
Averages.	4.33	4.26	4.41	3.24	3.33	2.93	3.77	4.16	3.23	4.37	4.22	3.68	45.83

* Means of observations at several places, as follows : January, 1875, to April, 1876, Lake Cochituate; April to June, 1876, Lake Cochituate, Westborough and Hopkinton; June to December, 1876, Lake Cochituate, Southborough, Marlborough, Westborough and Hopkinton; December, 1876, to January, 1883, Framingham, Southborough, Marlborough, Westborough and Hopkinton; January, 1883, to January, 1884, Framingham and Southborough; January, 1884, to January, 1890, Framingham and Westborough; January, 1890, to May, 1898, Framingham and Ashland Dam; June, 1898, to December, 1899, Framingham, Ashland Dam, Cordaville and Sudbury Dam.

TABLE No. 6. — *Rainfall collected, in Inches, on the Sudbury Watershed, 1875 to 1899.*

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals.
1875, .	0.184	2.411	2.862	5.263	2.119	1.501	0.573	0.706	0.368	1.152	2.248	1.041	20.418
1876, .	1.147	2.252	7.911	5.683	2.031	0.383	0.326	0.723	0.318	0.417	1.878	0.809	23.908
1877, .	1.174	1.529	8.586	4.183	2.482	1.081	0.360	0.216	0.103	1.127	2.447	2.300	23.487
1878, .	3.228	3.973	6.256	2.607	2.487	0.873	0.229	0.848	0.277	0.921	2.922	5.667	30.487
1879, .	1.249	2.756	4.156	6.379	1.987	0.713	0.261	0.705	0.243	0.126	0.355	0.825	18.775
1880, .	2.000	2.962	2.451	2.017	0.917	0.303	0.315	0.212	0.138	0.181	0.354	0.312	12.182
1881, .	0.740	2.491	7.142	2.669	1.721	2.309	0.493	0.264	0.340	0.331	0.682	1.383	20.665
1882, .	2.213	3.872	5.064	1.497	2.304	0.913	0.154	0.099	0.529	0.634	0.362	0.561	18.102
1883, .	0.597	1.664	2.873	2.530	1.673	0.518	0.206	0.140	0.157	0.331	0.354	0.345	11.188
1884, .	1.775	4.742	6.752	4.925	1.838	0.719	0.399	0.458	0.076	0.148	0.302	1.650	23.784
1885, .	2.203	2.182	2.806	3.133	2.383	0.735	0.111	0.429	0.209	0.569	2.033	2.064	18.916
1886, .	2.606	7.784	3.672	3.361	1.285	0.350	0.206	0.168	0.203	0.260	1.161	1.819	22.925
1887, .	4.619	4.558	6.116	4.522	1.799	0.714	0.204	0.392	0.191	0.339	0.636	1.147	24.227
1888, .	1.878	3.255	6.775	4.566	2.912	0.728	0.209	0.677	1.904	3.566	4.761	6.428	35.749
1889, .	2.963	1.926	2.388	2.434	1.669	1.128	1.130	2.554	1.422	2.194	3.351	3.997	29.056
1890, .	2.237	2.463	6.498	3.236	2.437	0.980	0.191	0.235	0.790	4.053	2.097	1.776	26.993
1891, .	5.333	5.616	7.944	4.138	1.039	0.714	0.266	0.290	0.350	0.526	0.626	0.971	27.612
1892, .	3.335	1.574	3.488	1.504	2.245	0.739	0.382	0.500	0.396	0.224	1.204	0.865	16.456
1893, .	0.773	2.485	5.789	3.668	5.143	0.759	0.282	0.322	0.187	0.396	0.560	1.421	21.774
1894, .	1.266	3.992	3.992	2.832	1.498	0.722	0.287	0.373	0.258	0.688	1.442	1.277	16.182
1895, .	1.844	0.871	4.299	4.341	1.134	0.301	0.411	0.409	0.153	2.460	4.794	3.179	24.196
1896, .	1.933	4.466	6.841	2.579	0.641	0.669	0.170	0.102	0.669	1.055	1.137	1.171	21.453
1897, .	1.507	1.718	4.575	2.615	1.632	1.661	1.174	1.053	0.315	1.570	2.827	2.827	30.315
1898, .	2.922	4.869	4.645	3.158	2.222	0.915	0.411	1.974	0.637	2.068	3.429	3.208	30.459
1899, .	4.082	2.225	7.501	4.351	0.911	0.114	0.035	-0.063	0.162	0.206	0.625	0.392	20.441
Totals, .	55.823	76.239	129.331	87.140	48.409	20.513	8.805	13.776	10.475	23.899	41.120	46.465	562.050
Averages, .	2.233	3.050	5.175	3.485	1.986	0.821	0.362	0.551	0.419	0.966	1.645	1.859	22.482

TABLE No. 7. — *Yield of the Sudbury Watershed in Gallons per Day per Square Mile* from 1875 to 1899.*

MONTH.	1875.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.	1886.	1887.
January,	103,000	643,000	658,000	1,810,000	700,000	1,120,000	415,000	1,241,000	335,000	995,000	1,235,000	1,461,000	2,589,000
February,	1,496,000	1,368,000	949,000	2,465,000	1,711,000	1,787,000	1,546,000	2,403,000	1,033,000	2,842,000	1,354,000	4,801,000	2,329,000
March,	1,604,000	4,435,000	4,814,000	3,597,000	2,380,000	1,374,000	4,004,000	2,839,000	1,611,000	3,785,000	1,572,000	2,089,000	2,868,000
April,	3,049,000	3,292,000	2,394,000	1,628,000	3,116,000	1,169,000	1,546,000	867,000	1,350,000	2,853,000	1,815,000	1,947,000	2,620,000
May,	1,188,000	1,188,000	1,391,000	1,394,000	1,114,000	514,000	965,000	1,292,000	987,000	1,080,000	1,386,000	720,000	1,009,000
June,	870,000	222,000	597,000	506,000	413,000	175,000	1,333,000	529,000	300,000	416,000	426,000	203,000	413,000
July,	321,000	183,000	292,000	128,000	187,000	176,000	276,000	86,000	116,000	224,000	62,000	116,000	116,000
August,	386,000	406,000	121,000	476,000	396,000	119,000	148,000	55,000	79,000	267,000	240,000	94,000	214,000
September,	297,000	184,000	60,000	161,000	141,000	80,000	197,000	307,000	91,000	44,000	121,000	117,000	111,000
October,	646,000	234,000	631,000	516,000	71,000	102,000	186,000	299,000	186,000	88,000	336,000	146,000	190,000
November,	1,302,000	1,083,000	1,413,000	1,683,000	206,000	205,000	396,000	209,000	205,600	175,000	1,177,000	673,000	389,000
December,	584,000	453,000	1,290,000	3,177,000	463,000	175,000	775,000	315,000	194,000	925,000	1,174,000	1,020,000	648,000
Average for year,	972,000	1,135,000	1,214,000	1,452,000	894,000	578,000	979,000	862,000	533,000	1,129,000	901,000	1,087,000	1,164,000
Average for driest 6 months,	574,000	384,000	502,000	532,000	230,000	143,000	330,000	211,000	145,000	200,000	391,000	223,000	234,000

* The area of the Sudbury watershed used in making up these records included water surfaces amounting to 1.9 per cent. of the whole area from 1875 to 1878 inclusive, and subsequently increased by the construction of storage reservoirs to 3.0 per cent. in 1879, 3.4 per cent. in 1886, 3.9 per cent. in 1894 and 6.5 per cent. in 1899. The watershed also contains extensive areas of swampy land, which, though covered with water at times, are not included in the above percentages of water surfaces.

TABLE No. 7.—Yield of the Sudbury Watershed in Gallons per Day per Square Mile * from 1875 to 1899—Concluded.

MONTH.	1888.	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	1897.	1898.	1899.	Mean for 25 Years, 1875-99.
January,	1,053,000	2,782,000	1,254,000	3,015,000	1,370,000	434,000	693,000	1,034,000	1,084,000	845,000	1,833,000	2,288,000	1,253,000
February,	1,950,000	1,196,000	1,529,000	3,485,000	943,000	1,542,000	991,000	541,000	2,676,000	1,087,000	3,022,000	1,381,000	1,877,000
March,	3,238,000	1,338,000	3,643,000	4,453,000	1,955,000	3,245,000	2,238,000	2,410,000	3,835,000	2,585,000	2,804,000	4,205,000	2,901,000
April,	2,645,000	1,410,000	1,876,000	2,397,000	871,000	2,125,000	1,640,000	2,515,000	1,494,000	1,515,000	1,829,000	2,521,000	2,019,000
May,	1,632,000	880,000	1,366,000	583,000	1,259,000	2,883,000	840,000	636,000	360,000	915,000	1,246,000	511,000	1,066,000
June,	421,000	653,000	568,000	413,000	428,000	440,000	419,000	174,000	399,000	962,000	530,000	66,000	475,000
July,	117,000	684,000	107,000	149,000	214,000	168,000	161,000	261,000	95,000	658,000	221,000	19,000	197,000
August,	379,000	1,432,000	182,000	163,000	280,000	181,000	209,000	229,000	57,000	591,000	1,107,000	—35,000	309,000
September,	1,155,000	823,000	457,000	203,000	229,000	108,000	150,000	89,000	388,000	182,000	360,000	94,000	243,000
October,	1,999,000	1,250,000	2,272,000	219,000	126,000	222,000	374,000	1,379,000	592,000	94,000	1,160,000	115,000	536,000
November,	2,768,000	1,941,000	1,215,000	305,000	697,000	319,000	836,000	2,777,000	659,000	909,000	1,886,000	804,000	953,000
December,	3,043,000	2,241,000	996,000	544,000	485,000	706,000	716,000	1,782,000	697,000	1,884,000	1,799,000	230,000	1,042,000
Average for year,	1,097,000	1,383,000	1,286,000	1,315,000	781,000	1,087,000	770,000	1,152,000	1,019,000	991,000	1,450,000	973,000	1,070,000
Average for driest 6 months,	953,000	944,000	747,000	239,000	327,000	237,000	356,000	460,000	314,000	564,000	777,000	93,000	450,000

* The area of the Sudbury watershed used in making up these records included water surfaces amounting to 1.9 per cent. of the whole area from 1875 to 1878 inclusive, and subsequently increased by the construction of storage reservoirs to 3.0 per cent. in 1879, 3.4 per cent. in 1886, 3.9 per cent. in 1894 and 6.5 per cent. in 1898. The watershed also contains extensive areas of swampy land, which, though covered with water at times, are not included in the above percentages of water surfaces.

TABLE No. 8. — *Sudbury River. — Statistics of Flow of Water, Storage and Rainfall in 1899.*

[Watered from 1875 to 1878 inclusive = 77.764 square miles; in 1879 and 1880 = 78.283 square miles; and from 1881 to 1899 inclusive = 75.2 square miles.]

MONTH.	Quantity of Water received through Wastewater Aqueduct (Gallons per Day).	Quantity of Water discharged through Sudbury Aqueduct (Gallons per Day).	Quantity of Water used by Framingham Water Company (Gallons per Day).	Quantity of Water diverted from Water-Sewers, etc. (Gallons per Day).	Quantity of Water wasted into Lowest Dam (Gallons per Day).	STORAGE.		Total Flow of Gallons per Day).	Rainfall (Inches).	Rainfall collected (Inches).	Percentage of Rainfall collected.
						Gain (Gallons per Day).	Loss (Gallons per Day).				
January, . . .	117,186,000	87,819,000	352,000	1,728,000	136,890,000	62,889,000	-	172,090,000	4.18	4.082	97.7
February, . . .	98,193,000	98,011,000	428,000	1,114,000	108,618,000	-	6,111,000	103,868,000	4.91	2.225	45.3
March, . . .	104,500,000	96,410,000	352,000	2,861,000	803,242,000	18,877,000	-	816,242,000	7.01	7.501	107.0
April, . . .	85,870,000	88,950,000	357,000	1,950,000	169,406,000	13,760,000	-	189,658,000	1.90	4.351	229.0
May, . . .	80,819,000	85,310,000	413,000	561,000	25,809,000	7,319,000	-	38,394,000	1.45	0.911	62.8
June, . . .	68,223,000	91,397,000	527,000	337,000	2,073,000	-	27,054,000	4,947,000	2.51	0.114	4.6
July, . . .	44,807,000	88,952,000	474,000	323,000	1,500,000	-	45,984,000	1,458,000	3.22	0.035	1.1
August, . . .	28,952,000	71,033,000	461,000	255,000	1,500,000	-	46,932,000	-2,835,000	1.43	-0.063	-4.4
September, . . .	29,507,000	66,547,000	417,000	236,000	1,500,000	-	35,140,000	7,053,000	3.95	0.162	4.1
October, . . .	24,848,000	66,665,000	393,000	235,000	1,500,000	-	35,271,000	8,674,000	2.69	0.206	7.6
November, . . .	42,920,000	80,723,000	404,000	236,000	4,980,000	-	20,560,000	22,863,000	2.18	0.525	24.1
December, . . .	37,345,000	90,332,000	423,000	235,000	15,116,000	-	52,729,000	16,532,000	1.78	0.392	22.0
Totals, . . .	-	-	-	-	-	-	-	-	37.21	20.441	-
Average for year,	68,975,000	84,716,000	416,000	796,000	64,213,000	-	13,976,000	73,190,000	-	-	54.9

TABLE No. 9. — *Lake Cochituate. — Statistics of Flow of Water, Storage and Rainfall in 1899.*

[Watershed of lake = 18.87 square miles.] *

MONTH.	Quantity of Water received through Sudbury Aqueduct (Gallons per Day).	Quantity of Water discharged through Cochituate Aqueduct (Gallons per Day).	Quantity of Water diverted from Water-shed by Sewers, etc. (Gallons per Day).	Quantity of Water wasted at Outlet (Gallons per Day).	STORAGE.		Quantity of Water collected in Lake (Gallons per Day).	Rainfall (Inches).	Rainfall collected (Inches).	Percentage of Rainfall collected.
					Gain (Gallons per Day).	Loss (Gallons per Day).				
January,	5,584,000	-	1,052,000	43,093,000	-	2,087,000	36,474,000	4.36	3.46	79.1
February,	4,643,000	-	775,000	46,268,000	-	15,593,000	27,107,000	4.44	2.31	52.1
March,	11,561,000	-	1,371,000	60,877,000	16,452,000	-	67,189,000	7.31	6.35	86.8
April,	10,467,000	-	1,027,000	37,683,000	2,800,000	-	31,043,000	1.70	2.84	167.1
May,	390,000	-	468,000	2,693,000	4,529,000	-	7,300,000	1.06	0.60	65.1
June,	43,000	-	190,000	843,000	257,000	-	1,247,000	2.79	0.11	4.1
July,	-	1,739,000	185,000	639,000	-	2,168,000	345,000	3.20	0.03	1.0
August,	-	14,219,000	49,000	-	-	13,310,000	955,000	2.17	0.09	4.2
September,	-	18,567,000	100,000	-	-	13,190,000	5,477,000	4.65	0.50	10.8
October,	-	18,487,000	164,000	-	-	12,032,000	6,619,000	3.05	0.63	20.5
November,	-	2,597,000	213,000	-	2,627,000	-	5,437,000	2.31	0.50	21.5
December,	-	-	187,000	-	4,107,000	-	4,294,000	1.92	0.41	21.1
Totals,	-	-	-	-	-	-	-	38.96	17.91	-
Average for year,	2,709,000	4,665,000	476,000	16,829,000	-	2,173,000	16,083,000	-	-	46.0

* Not including the watershed of Dudley Pond. No water was drawn from this pond during 1899.

TABLE No. 10. — *Elevations of Water Surfaces of Reservoirs above Boston City Base at the Beginning of Each Month.*

DATE.	Chestnut Hill Reservoir. Ordinary High Water =134.00.	Lake Cochituate. High Water =144.38.	Dudley Pond. High Water =156.46.	Spot Pond. High Water =166.25.	FRAMINGHAM RESERVOIR				Farm Pond. High Water =169.25.	Ashland Reservoir. Flash Boards 225.23.	Sudbury Reservoir. Flash Boards 259.97.	Hopkinton Reservoir. Flash Boards 305.00.	Whitehall Reservoir. High Water =337.91.
					No. 1. Flash Boards 169.27.	No. 2. Flash Boards 177.12.	No. 3. Flash Boards 186.50.						
Jan. 1, 1899, .	133.84	143.38	155.01	151.78	159.42	167.97	176.20	185.00	224.55	253.39	304.12	336.78	
Feb. 1, 1899, .	133.87	143.11	155.40	149.43	159.37	167.92	176.19	184.96	224.49	253.10	304.20	337.18	
March 1, 1899, .	134.45	141.20	155.78	147.44	159.30	168.82	176.46	185.14	220.87	258.86	300.55	336.60	
April 1, 1899, .	134.62	143.45	156.70	148.27	159.03	168.41	176.46	185.16	221.43	259.39	301.92	337.88	
May 1, 1899, .	133.95	143.79	156.60	143.67	159.11	167.86	176.17	185.10	224.37	259.97	304.22	337.41	
June 1, 1899, .	134.92	144.34	155.93	141.43	158.83	169.38	177.70	186.30	225.24	259.78	305.04	337.36	
July 1, 1899, .	134.60	144.37	155.23	141.23	158.94	169.09	176.22	185.20	225.18	258.28	304.82	337.31	
Aug. 1, 1899, .	134.40	144.11	154.62	141.38	158.51	168.65	175.80	185.02	223.87	255.25	304.61	337.11	
Sept. 1, 1899, .	133.01 } 133.54 }	142.39	154.08	141.44	158.66	167.99	176.73	183.47	222.05	252.17	304.29	336.87	
Oct. 1, 1899, .	133.51	140.58	153.72	139.85	158.49	167.69	176.72	177.80	212.14	252.28	301.47	336.88	
Nov. 1, 1899, .	132.64 } 134.72 }	138.75	153.50	139.40	158.36	167.32	177.00	185.35	196.32	251.25	285.27	336.99	
Dec. 1, 1899, .	132.30 } 134.47 }	139.15	153.28	139.38	158.67	167.64	175.95	184.00	193.88	250.36	280.25	337.09	
Jan. 1, 1900, .	134.47	139.78	153.12	144.20	158.52	157.60	175.01	184.01	195.21	245.06	280.54	337.07	

NOTE. — Where two elevations are given for Chestnut Hill Reservoir, the first refers to Bradley Basin and the second to Lawrence Basin.

TABLE No. 11. — *Times when the Sudbury and Cochituate Aqueducts have been in Service, and the Sources from which the Supply for the Sudbury Aqueduct has been drawn.*

Sudbury Aqueduct:—

From 7.00 A.M. Jan. 1 to 9.00 P.M. April 24,	from Framingham Reservoir No. 3.
From 6.00 P.M. April 25 to 9.00 P.M. May 8,	from Framingham Reservoir No. 3.
From 6.30 P.M. May 9 to 9.00 P.M. May 22,	from Framingham Reservoir No. 3.
From 7.30 P.M. May 23 to 9.00 P.M. June 1,	from Framingham Reservoir No. 3.
From 8.00 P.M. June 2 to 7.00 A.M. June 14,	from Framingham Reservoir No. 3.
From 7.15 P.M. June 14 to 3.00 P.M. June 16,	from Framingham Reservoir No. 3.
From 3.00 P.M. June 16 to 10.30 A.M. July 20,	from Framingham Reservoirs Nos. 2 and 3.
From 10.30 A.M. July 20 to 7.00 A.M. Aug. 15,	from Framingham Reservoir No. 3.
From 7.15 P.M. Aug. 15 to 11.00 A.M. Aug. 25,	from Framingham Reservoir No. 3.
From 11.00 A.M. Aug. 25 to 7.00 A.M. Nov. 11,	from Framingham Reservoirs Nos. 2 and 3.
From 7.00 A.M. Nov. 11 to 11.00 A.M. Nov. 13,	from Framingham Reservoir No. 3.
From 11.00 A.M. Nov. 13 to 7.00 A.M. Nov. 16,	from Framingham Reservoirs Nos. 2 and 3.
From 7.00 A.M. Nov. 16 to 7.00 A.M. Dec. 29,	from Framingham Reservoir No. 3.
From 7.00 A.M. Dec. 29 to 7.00 A.M. Jan. 1, 1900,	from Framingham Reservoirs Nos. 2 and 3.

Cochituate Aqueduct:—

From 2.45 P.M. July 28 to 3.00 P.M. Nov. 6.

TABLE NO. 12. — *Water supplied from Local Sources.*

MONTH.	Malden* (Million Gallons).	Medford† (Million Gallons).	Revere‡ (Million Gallons).	Nahant and Swamp- scott§ (Million Gallons).	Arlington|| (Million Gallons).	Total (Million Gallons).	Gallons per Day.
January, .	—	35.98	2.97	11.61	17.06	67.62	2,181,000
February, .	—	32.98	—	10.62	16.32	59.92	2,140,000
March, .	—	33.61	—	11.01	18.36	62.98	2,032,000
April, .	—	33.47	—	12.48	19.53	65.48	2,183,000
May, .	—	37.97	—	19.36	26.49	83.82	2,704,000
June, .	—	—	1.08	26.95	31.23	59.26	1,975,000
July, .	—	—	13.98	9.70	11.44	35.12	1,133,000
August, .	—	—	15.31	4.76	10.82	30.89	996,000
September, .	—	—	12.20	0.22	9.17	21.59	720,000
October, .	—	—	—	—	6.92	6.92	223,000
November, .	1.23	—	—	—	6.52	7.75	258,000
December, .	—	—	—	—	5.93	5.93	191,000
For the year,	1.23	174.01	45.54	106.71	179.79	507.28	1,390,000

* Malden supply from Eaton's wells.

† Medford supply from Wright's Pond and reservoir on west arm of brook.

‡ Revere supply from wells in Saugus.

§ Nahant and Swampscott supply from local sources discontinued August 21, 1899.

|| Arlington supply from storage reservoir and driven wells at East Lexington until June 30, 1899, and from wells alone thereafter.

TABLE NO. 13. — *Average Daily Quantity of Water flowing through Aqueducts in 1899, by Months.*

MONTH.	Wachusett Aqueduct (Gallons.)	SUDBURY AQUEDUCT.			Cochituate Aqueduct (Gallons).
		From Framingham Reservoir No. 3 (Gallons).	From Framingham Reservoir No. 2 (Gallons).	Total (Gallons).	
January, .	117,136,000	87,819,000	—	87,819,000	—
February, .	98,193,000	98,011,000	—	98,011,000	—
March, .	104,500,000	96,410,000	—	96,410,000	—
April, .	85,870,000	89,950,000	—	89,950,000	—
May, .	80,819,000	85,310,000	—	85,310,000	—
June, .	63,233,000	87,487,000	3,910,000	91,397,000	—
July, .	44,807,000	85,010,000	4,942,000	89,952,000	1,739,000
August, .	28,952,000	69,365,000	1,668,000	71,033,000	14,219,000
September, .	29,507,000	47,503,000	22,044,000	69,547,000	18,567,000
October, .	24,848,000	22,165,000	44,500,000	66,665,000	18,487,000
November, .	42,920,000	64,190,000	16,533,000	80,723,000	2,597,000
December, .	37,345,000	88,526,000	2,306,000	90,832,000	—
Averages, .	62,975,000	76,687,000	8,029,000	84,716,000	4,665,000

The Wachusett Aqueduct discharges into Sudbury Reservoir, whence the water flows into Framingham Reservoir No. 3.

Of the total quantity flowing through the Sudbury Aqueduct an average of 2,709,000 gallons per day flowed into Lake Cochituate, leaving an average of 82,007,000 gallons per day which was discharged into Chestnut Hill Reservoir.

TABLE No. 14. — *Statement of Operations of Engines Nos. 1 and 2 at Chestnut Hill Pumping Station for the Year 1899.*

[These engines were designed for high-service engines, but were used during the entire year for low service.]

1899. MONTHS.	ENGINE No. 1.			ENGINE No. 2.			Average Rate of Pumping per 24 Hours, 4 Per Cent. allowed for Slop.	Total Amount of Coal consumed (Pounds).	Total Amount of Ashes and Chinkers (Pounds).	Per Cent. of Ashes and Chinkers.	Quantity pumped per Pound of Coal, no Deduction for Heating or Light- ing (Gallons).	Average Lift (Feet).	Duty in Foot-pounds per 100 Pounds of Coal, no Deduction for Heating or Lighting, 4 Per Cent. allowed for Slop.	Duty in Foot-pounds per 100 Pounds of Coal, on Basis of Punger Displace- ment, no Deduc- tion for Heating or Lighting.
	Hrs. Min.	Total Pumping Time.	Amount pumped, 4 Per Cent. al- lowed for Slop. (Million Gal- lons).	Hrs. Min.	Total Pumping Time.	Amount pumped, 4 Per Cent. al- lowed for Slop. (Million Gal- lons).								
January, . . .	703 40	280.12	306.62	740 15	306.62	596.74	19.89	286,678	16,335	5.7	2,081.56	32.16	55,830,000	58,170,000
February, . . .	668 05	327.20	323.61	669 20	323.61	655.81	23.51	352,189	20,750	5.9	1,862.11	38.95	60,490,000	63,030,000
March, . . .	740 57	391.51	393.57	743 05	393.57	785.08	25.41	456,319	28,336	6.2	1,720.47	43.01	61,710,000	64,300,000
April, . . .	670 05	309.60*	309.60*	598 35	276.28*	585.86	22.19	369,135	23,121	6.3	1,587.12	40.75	53,940,000	56,210,000
May, . . .	710 20	350.65	350.65	744 00	367.67	718.32	23.71	414,309	26,369	6.4	1,733.78	42.75	61,810,000	64,410,000
June, . . .	720 00	358.45	358.45	712 55	355.13	713.58	23.87	432,562	34,416	8.0	1,649.70	48.07	66,140,000	68,920,000
July, . . .	737 00	350.35	350.35	734 40	350.16	700.51	22.82	418,746	34,138	8.2	1,672.87	46.06	64,220,000	66,960,000
August, . . .	742 25	390.21	390.21	744 00	360.78	720.99	23.26	470,700	38,531	8.2	1,531.75	45.86	58,680,000	61,040,000
September, . . .	660 20	312.47	312.47	713 20	341.69	654.16	22.87	450,715	35,135	7.8	1,451.38	45.34	54,880,000	57,180,000
October, . . .	530 05	250.93	250.93	534 00	253.24	504.17	22.71	326,270	26,573	8.1	1,545.24	44.96	57,040,000	60,370,000
November, . . .	96 05	44.73	44.73	94 58	43.91	83.64	22.16	64,822	4,221	6.5	1,367.44	44.06	50,250,000	52,360,000
December, . . .	338 15	152.02	152.02	442 00	201.97	353.99	21.72	216,552	13,131	8.4	1,634.07	45.53	62,070,000	64,680,000
Totals and averages,	7,317 27	3,498.24	3,679.61	7,471 08	3,679.61	7,077.85	22.08	4,258,987	306,056	7.2	1,661.80	43.13	59,780,000	62,290,000

* In April 10 per cent. deducted for defective valves, in addition to the regular 4 per cent. allowance for slop.

TABLE NO. 15. — *Statement of Operations of Engine No. 3 at Chestnut Hill Pumping Station for the Year 1899.*

[This engine was designed for high service, but was used for low service from October 23 to December 12, inclusive.]

1899. MONTHS.	Total Pumping Time.	Hrs. Min.	Amount pumped, 3 Gallons.	Average Rate of pumping per 24 Hours, 3 Per Cent. allowed for Slop (Million Gallons).	Amount of Coal consumed (Pounds).	Amount of Ashes and Clinkers (Pounds).	Per Cent. of Ashes and Clinkers.	Quantity pumped per Pound of Coal, no Deduction for Heating or Light- ing (Gallons).	Average Lift (Feet).	Duty in Root-pounds per 100 Pounds of Coal, no Deduction for Heating or Lighting, 3 Per Cent. allowed for Slop.	Duty in Root-pounds per 100 Pounds of Coal, on Basis of Punger Displacement, no Deduction for Heating or Lighting.
January..	.	648 57	561.99	20.81	535,782	30,609	5.7	1,045.92	119.45	104,490,000	107,660,000
February,	.	356 10	332.35	22.46	295,549	16,355	5.5	1,124.52	119.80	112,360,000	115,750,000
March,	.	739 00	672.49	21.83	563,083	36,678	6.2	1,133.89	118.95	112,490,000	115,900,000
April,	.	346 00	297.74	20.68	256,697	16,659	6.5	1,156.89	118.90	115,020,000	118,500,000
May,	.	188 15	156.05	20.01	130,103	8,839	6.8	1,199.46	118.82	118,860,000	122,460,000
June,
July,
August,	.	139 40	125.61	21.66	102,865	8,779	8.5	1,221.10	121.67	123,910,000	127,660,000
September,
October, high service,	.	4 15	4.02	.	2,939	265	9.0	.	123.41	.	.
October, low service,	.	209 45	224.76	25.83	112,335	9,259	8.2	2,000.78	49.06	81,560,000	84,340,000
November, low service,	.	609 00	665.83	26.21	346,136	27,979	8.1	1,923.60	50.90	81,660,000	84,130,000
December, high service,	.	87 45	79.48	21.48	67,076	5,383	8.0	1,184.92	123.10	121,650,000	125,540,000
December, low service,	.	609 20	631.19	24.85	320,999	28,432	8.9	1,966.33	45.52	74,650,000	77,940,000
Totals and averages	{ high service, low service,	2,510 02	2,229.73	21.82	1,984,095	123,567	6.2	1,125.80	120.51	112,950,000	116,560,000
		1,428 05	1,521.78	25.58	779,471	65,680	8.4	1,952.32	48.49	78,950,000	81,480,000

NOTE. — 87 million gallons pumped to high service and diverted to low service through by-pass.

TABLE No. 16. — *Statement of Operations of Engine No. 4 at Chestnut Hill Pumping Station for the Year 1899.*

1899. MONTHS.	Total Pumping Time Hrs. Min.	Amount pumped, 1 Per Cent. allowed for Sump (Million Gallons).	Average Rate of Pumping per 24 Hours, 1 Per Cent. allowed for Sump (Million Gallons).	Amount of Coal con- sumed (Pounds).	Amount of Ashes and Clinkers (Pounds).	Per Cent. of Ashes and Clinkers.	Quantity pumped per Pound of Coal, no Deduction for Heating or Light- ing (Gallons).	Average Lift (Feet).	Daily in Root-pounds per 100 Pounds of Coal, no Deduction for Heating or Lighting.	Daily in Root-pounds per 100 Pounds of Coal, no Deduction for Heating or Lighting.	SUMMARY, ENGINES Nos. 1, 2, 3 AND 4.	
											Total Amount pumped, Al- lowance made for Sump (Mil- lion Gallons).	Daily Aver- age Amount pumped (Mil- lion Gallons).
January, . . .	89 28	91.21	24.65	86,646	5,118	5.9	1,052.67	120.09	105,430,000	106,480,000	1,249.94	40.32
February, . . .	302 41	328.74	26.09	289,518	16,120	5.6	1,185.47	121.65	115,200,000	116,350,000	1,316.90	47.03
March, . . .	-	-	-	-	-	-	-	-	-	-	1,457.57	47.02
April, . . .	380 50	368.28	24.55	289,093	18,429	6.4	1,273.93	118.30	125,690,000	126,950,000	1,251.88	41.73
May, . . .	544 35	502.01	22.12	405,401	25,370	6.5	1,238.31	118.57	122,450,000	123,670,000	1,376.38	44.40
June, . . .	711 35	828.56	27.99	651,949	52,763	8.1	1,270.90	121.57	128,850,000	130,140,000	1,542.14	51.41
July, . . .	737 55	854.55	27.84	682,218	48,008	7.4	1,310.22	124.96	136,550,000	137,920,000	1,555.06	50.17
August, . . .	600 50	690.83	27.63	599,026	41,763	7.9	1,305.85	125.41	136,580,000	137,950,000	1,537.43	49.59
September, . . .	711 45	821.42	27.66	599,462	52,086	8.7	1,370.27	125.74	143,700,000	145,140,000	1,475.58	49.19
October, . . .	738 00	766.06	24.87	536,750	41,059	7.7	1,427.21	124.65	148,370,000	149,850,000	1,499.01	48.35
November, . . .	714 00	651.88	21.88	423,216	31,569	7.6	1,540.80	122.55	157,430,000	159,000,000	1,406.35	46.88
December, . . .	856 00	546.05	20.00	353,451	28,823	8.2	1,544.90	121.72	156,890,000	158,400,000	1,610.71	51.96
Totals and averages, .	6,167 39	6,449.59	25.09	4,816,728	362,088	7.5	1,339.00	122.29	136,560,000	137,930,000	1,278.95	47.34

NOTE. — 948.82 million gallons pumped by Engine No. 4 and diverted to low service through by-pass.

TABLE No. 17. — *Statement of Operations at West Roxbury Pumping Station for the Year 1899.*

1899. MONTH.	Total Pumping Time.	Total Amount pumped, Allowance being made for Slip (Million Gallons).	Daily Average Amount pumped (Million Gallons).	Amount of Coal consumed (Pounds).	Amount of Ashes and Clinkers (Pounds).	Per Cent. of Ashes and Clinkers.	Quantity pumped per Pound of Coal (Gallons).
	Hrs. Min.						
January, . . .	495 00	7.19	.232	41,675	6,755	16.2	173
February, . . .	450 00	6.83	.244	39,500	6,729	17.0	173
March, . . .	496 00	7.68	.248	42,650	7,945	18.6	180
April, . . .	481 00	7.84	.261	42,835	8,463	19.8	183
May, . . .	518 45	8.72	.281	49,090	9,540	19.4	178
June, . . .	659 45	11.83	.394	66,700	12,840	19.3	177
July, . . .	680 15	12.32	.397	69,840	13,520	19.4	176
August, . . .	620 45	11.23	.362	61,590	11,860	19.3	182
September, . . .	570 30	8.86	.295	46,780	8,900	19.0	181
October, . . .	681 30	12.14	.392	63,550	12,400	19.5	191
November, . . .	542 30	8.47	.282	46,830	8,980	19.2	181
December, . . .	516 30	7.85	.253	43,450	8,490	19.5	181
Totals and averages, . . .	6,712 30	110.96	.304	614,490	116,422	18.9	180

Average lift, 122.0 feet.

TABLE No. 18. — *Average Daily Consumption of Water in Cities and Towns in the Metropolitan Water District and the Town of Swampscott supplied Wholly or in Part by the Metropolitan Works.*

MONTH.	Supplied by Metropolitan Works (Million Gallons).	Supplied from Local Sources (Million Gallons).	Total (Million Gallons).	Estimated Population.	Consumption per Capita (Gallons).
January,	91.273	2.181	93.454	792,100	118
February,	98.188	2.140	100.328	794,100	126
March,	85.147	2.032	87.179	796,000	109
April,	81.088	2.183	83.271	798,000	104
May,	82.792	2.704	85.496	799,900	107
June,	91.224	1.975	93.199	801,800	116
July,	91.562	1.133	92.695	803,800	115
August,	87.286	.996	88.282	805,700	110
September,	87.134	.720	87.854	807,600	109
October,	85.719	.223	85.942	809,600	106
November,	82.890	.258	83.148	811,500	102
December,	82.278	.191	82.469	813,400	101
For the year,	87.143	1.390	88.533	802,800	110

TABLE No. 19. — *Average Daily Consumption of Water from the Low Service.*

MONTH.	BOSTON.	SOMERVILLE, CHELSEA, EVERETT, MALDEN, MEDFORD, CHARLESTOWN, EAST BOS- TON, MELROSE AND ARLINGTON.				Total Low-service Consumption (Million Gallons).
	Gravity Supply from Chestnut Hill Reservoir (Million Gallons)	Pumped at Chestnut Hill Reservoir (Million Gallons).	Gravity Supply from Spot Pond (Million Gallons).	Gravity Supply to Medford from Wright's Pond (Million Gallons).	Gravity Sup- ply to Arlington from Local Storage Reservoir (Million Gallons).	
January, . . .	42.278	15.571	7.619	.658	.381	66.507
February, . . .	45.772	21.021	4.365	.686	.404	72.248
March, . . .	37.134	22.090	—	.611	.410	60.245
April, . . .	38.560	18.577	—	.652	.451	58.240
May, . . .	38.231	19.357	—	.648	.592	58.828
June, . . .	39.945	21.514	—	—	.721	62.180
July, . . .	41.409	20.174	—	—	—	61.583
August, . . .	37.676	20.309	—	—	—	57.985
September, . . .	38.151	19.750	—	—	—	57.901
October, . . .	37.841	19.559	—	—	—	57.400
November, . . .	36.586	18.649	—	—	—	55.235
December, . . .	36.097	21.498	—	—	—	57.595
For the year, .	39.095	20.325	.488	.269	.245	60.422

TABLE No. 20. — *Average Daily Consumption of Water from the Southern High Service.*

MONTH.	Pumped at Chestnut Hill High-service Sta- tion for the Supply of Boston, Quincy, Water- town and Belmont (Million Gallons) *	MONTH.	Pumped at Chestnut Hill High-service Sta- tion for the Supply of Boston, Quincy, Water- town and Belmont (Million Gallons) *
January,	20.839	August,	21.594
February,	21.420	September,	20.545
March,	20.807	October,	20.656
April,	18.699	November,	20.300
May,	19.346	December,	18.632
June,	21.951	For the year,	20.637
July,	21.930		

* This does not include water pumped from southern high-service mains for southern extra high service, at the West Roxbury Pumping Station.

TABLE No. 21. — *Average Daily Consumption of Water, in Million Gallons, from the Northern High Service, supplying Revere and Winthrop, Swampscott and Nahant, Breeds Island and the Higher Portions of Chelsea, Everett, Malden, Medford, Melrose and Somerville.*

1899. MONTHS.	Pumped at Chelsea Station.	Pumped at Ever- ett Station.	Pumped at Malden Station.	Pumped at Med- ford Station.	Pumped at Mel- rose Station.	Pumped at Revere Water Co.'s Sau- gus Station.	Pumped at Somer- ville Station.	Pumped at Swamp- scott Station.*	Total Northern High-service Pumpage.	Storage in North- ern High-service Reservoir.	Total Northern High-service Consumption.
January, . . .	.774	-	1.656	.503	1.036	.096	1.268	.374	5.707	-	5.707
February, . . .	.789	-	1.891	.492	1.095	-	1.591	.379	6.237	-	6.237
March, . . .	.477	-	2.089	.473	1.023	-	1.281	.355	5.698	-	5.698
April, . . .	.548	-	2.166	.464	.784	-	1.492	.416	5.870	-	5.870
May, . . .	1.167	.004	2.148	.577	.043	-	2.214	.625	6.778	-	6.778
June, . . .	1.473	.583	3.017	.304	-	.036	2.043	.898	8.354	-	8.354
July, . . .	1.554	.350	3.057	.750	-	.451	1.941	.313	8.416	-	8.416
August, . . .	1.535	.383	2.792	.854	-	.494	1.780	.154	7.992	-	7.992
September, . .	1.387	.148	2.700	.977	-	.407	2.379	.007	8.005	+ .199	7.806
October, . . .	1.562	-	2.816	1.034	-	-	2.380	-	7.792	+ .521	7.271
November, . . .	1.521	-	2.886	1.005	-	-	2.205	-	7.617	+ .503	7.114
December, . . .	1.494	-	2.194	.070	-	-	2.032	-	5.790	- .007	5.797
For the year,	1.193	.123	2.453	.625	.327	.125	1.885	.292	7.023	+ .101	6.922

* Previous to June 30 Swampscott and Nahant were supplied from the Swampscott station, pumping from driven wells. From June 30 to August 21 a portion of the supply, and after August 21 the entire supply, was obtained from the Metropolitan Works, except a small quantity pumped in September, while work was being done on the Metropolitan Works supply main.

TABLE No. 22. — *Average Daily Consumption of Water from the Southern Extra High Service in West Roxbury and the Northern Extra High Service in Arlington.*

MONTH.	Southern Extra High Service, West Roxbury (Gallons).	Northern Extra High Service, Arlington (Gallons).
January, . . .	232,000	169,000
February, . . .	244,000	179,000
March, . . .	248,000	182,000
April, . . .	261,000	200,000
May, . . .	281,000	263,000
June, . . .	394,000	320,000
July, . . .	397,000	369,000
August, . . .	362,000	349,000
September, . .	295,000	306,000
October, . . .	392,000	223,000
November, . . .	282,000	217,000
December, . . .	253,000	191,000
For the year, . . .	304,000	248,000

TABLE No. 23. — *Consumption of Water in the Metropolitan Water District as constituted December 31, 1899, and the Town of Swampscott, 1893-99.*

[Gallons per Day.]

MONTH.	1893.	1894.	1895.	1896.	1897.	1898.	1899.
January,	74,703,000	67,034,000	68,464,000	82,350,000	84,833,000	83,270,000	95,816,000
February,	71,355,000	68,414,000	79,835,000	86,605,000	83,389,000	86,833,000	102,794,000
March,	67,147,000	62,188,000	68,998,000	85,584,000	82,164,000	84,794,000	89,527,000
April,	61,820,000	57,128,000	62,368,000	76,932,000	79,324,000	75,879,000	85,777,000
May,	60,500,000	60,060,000	64,542,000	72,642,000	76,112,000	75,886,000	88,577,000
June,	62,732,000	67,603,000	69,134,000	76,818,000	77,228,000	82,596,000	96,639,000
July,	68,507,000	72,903,000	68,928,000	79,102,000	84,765,000	87,259,000	95,852,000
August,	66,336,000	67,260,000	71,498,000	77,713,000	83,395,000	86,735,000	91,120,000
September,	64,075,000	66,462,000	73,026,000	73,467,000	83,575,000	87,496,000	90,627,000
October,	63,199,000	62,170,000	66,412,000	71,101,000	78,865,000	81,093,000	88,749,000
November,	60,647,000	61,695,000	64,312,000	71,309,000	72,121,000	77,540,000	85,907,000
December,	66,192,000	64,623,000	69,921,000	78,900,000	75,998,000	85,705,000	85,110,000
Average for the year, .	65,590,000	64,782,000	68,882,000	77,688,000	80,144,000	82,914,000	91,299,000
Population,	708,391	728,254	748,117	772,300	796,800	821,000	845,800
Consumption per inhabitant,	92.6	89.0	92.1	100.6	100.6	101.0	107.9

The consumption for 1899, given in this table, differs from that given in Table No. 19, because this table includes, in addition, the consumption of water in Newton and Hyde Park, which received no water from the Metropolitan Works in 1899.

Note relating to Chemical Examinations of Water, Tables Nos. 24-30.

The chemical examinations contained in the tables were made by the State Board of Health. Colors have been determined by the Nessler standard, but the corresponding values by the platinum standard are also given for the purpose of comparison with colors determined in the laboratory of the Metropolitan Water Board as given in subsequent tables. The odor recorded is taken in such a way that it is a much stronger odor than would be noticed in samples drawn directly from a tap or collected directly from a reservoir. In nearly all cases the samples are collected and examined monthly; in the case of the Sudbury Reservoir, however, they are made weekly.

TABLE No. 24. — *Chemical Examinations of Water from the Nashua River above the Temporary Dam at Clinton.*

[Parts per 100,000.]

Number.	Date of Collection.	APPEARANCE.			ODOR.		RESIDUE ON EVAPORATION.		AMMONIA.				NITROGEN AS		Oxygen Consumed.	Hardness.		
		Turbidity.	Sediment.	COLOR.		Cold.	Hot.	Total.	Loss on Ignition.	Free.	ALUMINOID.			Nitrates.			Nitrites.	
				Neessler Standard.	Transformed to Platinum Standard.						Total.	Dissolved.	Suspended.					Chlorine.
1899.																		
26318	Jan. 2	V. slight.	V. slight.	.33	.35	Very faintly vegetable.	Faintly vegetable.	3.40	1.25	.0006	.0160	.0140	.0020	.24	.0060	.0002	.42	0.8
26390	Jan. 31	V. slight.	V. slight.	.22	.27	None.	Faintly vegetable.	2.75	1.10	.0002	.0104	.0082	.0022	.13	.0020	.0001	.36	0.8
26359	Feb. 28	Slight.	Slight.	.21	.27	None.	Faintly unpleasant.	2.90	1.10	.0014	.0116	.0002	.0024	.15	.0100	.0000	.29	0.6
26655	Apr. 3	Slight.	V. slight.	.20	.26	Very faintly vegetable.	Faintly vegetable.	2.70	1.15	.0008	.0158	.0138	.0020	.14	.0060	.0000	.32	0.3
26679	May 1	Slight.	Slight.	.34	.35	Faintly vegetable.	Distinctly vegetable.	3.10	1.15	.0034	.0196	.0172	.0024	.16	.0070	.0000	.42	0.5
27286	May 31	V. slight.	Slight.	.32	.34	Very faintly vegetable.	Faintly vegetable.	3.05	1.20	.0036	.0176	.0152	.0024	.18	.0050	.0000	.34	1.0
27657	July 5	Decided.	Cons.	.40	.39	Faintly vegetable.	Distinctly vegetable.	3.90	1.35	.0014	.0210	.0186	.0024	.17	.0030	.0001	.62	1.1
27937	July 31	V. slight.	V. slight.	.26	.30	Faintly vegetable.	Distinctly vegetable.	4.25	1.80	.0012	.0242	.0206	.0036	.17	.0050	.0000	.44	1.4
28423	Aug. 31	Slight.	Cons.	.30	.33	Faintly vegetable.	Faintly vegetable.	4.55	1.80	.0020	.0196	.0170	.0026	.21	.0040	.0001	.46	0.8
28854	Oct. 2	Slight.	Slight.	.30	.33	Very faintly vegetable.	Faintly vegetable.	4.85	1.60	.0016	.0186	.0162	.0024	.25	.0040	.0001	.41	0.8
29202	Oct. 31	Slight.	Slight.	.31	.34	V. faintly vegetable and unpleasant.	Faintly musty.	4.55	1.35	.0026	.0270	.0246	.0024	.30	.0050	.0001	.37	1.3
29524	Nov. 28	Decided.	Slight.	.40	.39	Faintly vegetable.	Faintly vegetable.	4.15	1.25	.0006	.0252	.0188	.0064	.26	.0070	.0001	.43	1.3
Av....	.....	.....	.....	.30	.33	.....	.....	3.65	1.34	.0016	.0189	.0161	.0028	.20	.0063	.0001	.40	0.9

TABLE No. 25. — *Chemical Examinations of Water from Framingham Reservoir No. 3.*

[Parts per 100,000.]

Number.	Date of Collection.	APPEARANCE.			ODOR.		RESIDUE ON EVAPORATION.		AMMONIA.				NITROGEN AS		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	COLOR.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	Total.	Dissolved.	Suspended.	Nitrate.	Nitrite.		
				Nessler Standard Transformed to Platinum Standard.												
25822	1899. Jan. 2	Slight.	Slight.	.50	None.	Very faintly vegetable.	5.05	1.40	.0036	.0144	.0124	.0020	.0180	.0002	.51	1.8
26082	Jan. 31	Slight.	V. slight.	.33	None.	Very faintly vegetable.	4.40	1.70	.0014	.0124	.0112	.0012	.0220	.0001	.46	1.6
26348	Feb. 28	V. slight.	V. slight.	.82	None.	Very faintly vegetable.	4.15	1.40	.0040	.0120	.0110	.0010	.0140	.0002	.44	1.4
26638	April 3	V. slight.	V. slight.	.25	Very faintly vegetable.	Faintly vegetable.	3.05	1.35	.0028	.0116	.0100	.0016	.0120	.0001	.36	0.5
26671	May 1	V. slight.	Slight.	.22	Very faintly vegetable.	Distinctly vegetable.	3.10	1.16	.0004	.0146	.0116	.0030	.0100	.0001	.30	0.6
27277	May 31	Slight.	Slight, cons. cyclops.	.21	Faintly vegetable.	Distinctly vegetable and faintly grassy.	2.90	1.30	.0014	.0148	.0124	.0024	.0090	.0001	.30	0.6
27647	July 5	V. slight.	Slight.	.19	Faintly vegetable.	Faintly vegetable.	3.15	1.00	.0000	.0152	.0128	.0024	.0020	.0001	.32	1.3
27925	July 31	V. slight.	Slight.	.12	Faintly vegetable.	Distinctly vegetable.	3.55	1.20	.0000	.0182	.0148	.0034	.0010	.0000	.34	1.0
28408	Aug. 31	V. slight.	V. slight.	.15	Very faintly vegetable.	Faintly vegetable.	3.55	1.40	.0002	.0168	.0142	.0026	.0010	.0000	.30	1.0
28836	Oct. 2	Slight.	Slight.	.10	Very faintly vegetable.	Faintly vegetable.	3.25	1.05	.0004	.0206	.0184	.0022	.0020	.0000	.31	0.8
29104	Oct. 31	V. slight.	V. slight.	.11	Faintly vegetable.	Faintly vegetable.	3.35	1.10	.0014	.0170	.0152	.0018	.0060	.0001	.28	1.0
29315	Nov. 23	V. slight.	Slight.	.11	None.	Faintly vegetable.	3.55	1.35	.0028	.0152	.0138	.0014	.0030	.0001	.26	1.1
A 4	.....	.....	.....	.22	.....	.....	3.50	1.28	.0016	.0152	.0131	.0021	.0082	.0001	.35	1.1

TABLE No. 26. — *Chemical Examinations of Water from Lake Cochituate.*

[Parts per 100,000.]

Number.	Date of Collection.	APPEARANCE.			ODOR.		RESIDUE ON EVAPORA- TION.		AMMONIA.				Chlorine.		NITROGEN AS		Oxygen Consumed.	Hardness.
		Turbidity.	Sediment.	COLOR.		Cold.	Hot.	Total.	Loss on Ignition.	Free.	ALBUMINOID.			Suspended.	Nitrates.	Nitrites.		
				Keasler Standard.	Transformed to Platinum Stand- ard.						Total.	Dissolved.						
1899.																		
256821	Jan. 2	Slight.	Cons.	.37	.37	Distinctly cucum- ber, synura.	Distinctly cucum- ber, synura.	5.25	1.90	.0020	.0462	.0314	.0148	.55	.0100	.0002	.62	2.2
26091	Jan. 31	Slight.	Slight.	.46	.43	Faintly vegetable.	Dis. veg., sweet & faintly cucumber.	6.40	2.40	.0012	.0304	.0234	.0070	.51	.0110	.0001	.68	2.2
26349	Feb. 28	V. slight.	Slight.	.33	.35	Distinctly musty, decaying, synura.	Distinctly musty, decaying, synura.	5.00	2.00	.0036	.0218	.0176	.0042	.40	.0180	.0001	.54	1.8
26645	Apr. 3	Slight.	Slight.	.31	.34	Very faintly vegetable.	Distinctly vegetable.	4.65	1.95	.0010	.0184	.0150	.0034	.38	.0110	.0000	.48	1.4
26978	May 1	V. slight.	Slight.	.26	.30	Faintly vegetable.	Distinctly vegetable.	4.65	1.65	.0016	.0220	.0180	.0040	.38	.0150	.0003	.42	1.4
27287	May 31	V. slight.	Slight.	.20	.26	Faintly vegetable.	Distinctly vegetable and pleasant.	4.95	1.60	.0046	.0284	.0236	.0048	.42	.0110	.0002	.37	1.7
27655	July 5	V. slight.	V. slight.	.15	.22	None.	Very faintly vegetable.	4.05	1.15	.0008	.0158	.0146	.0012	.43	.0060	.0002	.43	1.7
27926	July 31	None.	V. slight.	.09	.17	Faintly vegetable.	Faintly vegetable.	4.35	1.30	.0004	.0162	.0158	.0004	.39	.0050	.0001	.36	1.3
28415	Aug. 31	V. slight.	V. slight (also acum).	.10	.18	Faintly vegetable.	Distinctly vegetable and grassy.	4.60	1.95	.0004	.0180	.0168	.0012	.38	.0020	.0000	.34	1.6
28846	Oct. 2	V. slight.	Cons.	.09	.17	Faintly vegetable.	Distinctly vegetable and faintly grassy.	4.10	1.30	.0012	.0216	.0194	.0022	.44	.0060	.0000	.33	1.7
29200	Oct. 31	V. slight.	V. slight.	.10	.18	Faintly vegetable.	Faintly vegetable.	4.40	1.35	.0016	.0220	.0200	.0020	.42	.0060	.0001	.32	1.7
29506	Nov. 28	Slight.	Slight (also acum).	.22	.27	Faintly vegetable.	Distinctly vegetable and grassy.	4.45	1.65	.0056	.0176	.0156	.0020	.43	.0070	.0002	.31	1.7
Av....	.....	.....	.....	.22	.27	.....	.....	4.74	1.68	.0020	.0232	.0193	.0039	.43	.0090	.0001	.43	1.7

TABLE No. 27. — *Chemical Examinations of Water from Spot Pond, Stoneham.*

[Parts per 100,000.]

Number.	Date of Collection.	APPEARANCE			ODOR.		RESIDUE ON EVAPORA- TION.		AMMONIA.				NITROGEN AS		Oxygen Consumed.	Hardness.	
		Turbidity.	Sediment.	COLOR.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	ALBUMINOID.		Nitrates.	Nitrites.				
										Total.	Dissolved.			Suspended.			Chlorine.
1899.																	
25816	Jan. 2	Slight.	Slight, cons. cyclops.	.40	Distinctly disagreeable.	Distinctly disagreeable.	4.75	1.85	.0004	.0284	.0224	.0040	.41	.0020	.0002	.56	1.7
26112	Feb. 2	Slight.	V. slight.	.38	Distinctly disagreeable.	Distinctly disagreeable.	4.85	2.00	.0006	.0260	.0208	.0052	.40	.0030	.0001	.63	1.8
26345	Feb. 23	Slight.	V. slight.	.41	Distinctly disagreeable.	Decidedly fishy and disagreeable.	4.50	2.10	.0006	.0278	.0218	.0060	.42	.0060	.0001	.62	1.7
26634	Apr. 3	Slight.	V. slight, cons. cyclops.	.57	Strongly fishy and disagreeable.	Offensive.	4.60	1.80	.0028	.0260	.0212	.0048	.42	.0110	.0001	.60	1.4
26991	May 2	Decided.	Cons.	.38	Very disagreeable.	Offensive.	4.85	2.10	.0004	.0348	.0204	.0144	.36	.0040	.0000	.52	1.4
27272	May 31	Slight.	Cons.	.40	Offensive.	Offensive.	5.00	2.25	.0002	.0380	.0242	.0138	.42	.0020	.0000	.54	2.5
27638	July 5	Decided.	Cons.	1.15	Distinctly unpleas- ant and mouldy.	Distinctly unpleas- ant and decayed.	3.30	0.65	.0188	.0128	.0084	.0044	.21	.0020	.0000	.23	1.0
27920	July 31	Slight.	Slight.	.16	Faintly disagreeable.	Distinctly disagreeable.	2.65	0.75	.0130	.0110	.0094	.0016	.21	.0010	.0000	.19	0.8
28418	Aug. 31	Slight.	Slight.	.20	Very disagreeable.	Very disagreeable.	7.40	2.25	.0004	.0294	.0242	.0052	.42	.0020	.0000	.45	2.3
28845	Oct. 2	Decided.	Cons.	.11	Faintly vegetable.	Distinctly vegetable and grassy.	7.30	2.00	.0004	.0352	.0288	.0064	.38	.0040	.0000	.38	3.0
29218	Nov. 1	Slight.	Slight.	.18	Faintly vegetable.	Decidedly vegetable.	8.45	2.10	.0128	.0280	.0200	.0080	.42	.0020	.0000	.29	3.6
29505	Nov. 23	Decided.	V. slight.	.21	Faintly unpleasant.	Distinctly unpleasant.	10.15	2.15	.0294	.0193	.0170	.0023	.44	.0020	.0001	.31	4.0
Average				.38	.....	.....	5.65	1.83	.0066	.0282	.0199	.0063	.38	.0034	.0000	.44	2.1

Water from Spot Pond was not used for the supply of the Metropolitan District after April 24.

TABLE No. 28.—*Chemical Examinations of Water from a Faucet at the State House, Boston.*

[Parts per 100,000.]

Number.	Date of Collection.	APPEARANCE.			ODOR.		RESIDUE ON EVAPORA- TION.		AMMONIA.				NITROGEN AS		Oxygen Consumed.	Hardness.	
		Turbidity.	Sediment.	COLOR. NesslerStandard. Transformed to PlatinumStand- ard.	Cold.	Hot.	Total.	Loss on Ignition.	Free.	ALBUMINOID.			Nitrates.	Nitrites.			
Total.	Dissolved.									Suspended.	Chlorine.						
1899. 25809 Jan. 2	Slight.	V. slight.	.46	.43	None.	Very faintly vegetable.	5.55	1.75	.0020	.0158	.0130	.0028	.33	.0300	.0001	.49	2.0
26110 Feb. 2	V. slight.	V. slight.	.33	.35	Very faintly vegetable.	Faintly vegetable.	4.10	1.35	.0012	.0124	.0102	.0022	.28	.0200	.0001	.42	1.4
26360 Mar. 1	V. slight.	V. slight.	.30	.33	None.	Very faintly vegetable.	4.15	1.35	.0014	.0114	.0108	.0006	.26	.0220	.0002	.39	1.3
26630 Apr. 3	V. slight.	Slight.	.21	.27	Very faintly vegetable.	Faintly vegetable.	3.20	1.25	.0010	.0108	.0106	.0002	.21	.0190	.0002	.34	0.8
26995 May 2	V. slight.	V. slight.	.18	.24	Faintly vegetable and mouldy.	Distinctly vegetable.	3.45	1.10	.0004	.0108	.0092	.0016	.22	.0300	.0001	.30	1.0
27303 June 2	V. slight.	Slight.	.18	.24	Faintly vegetable.	Distinctly vegetable.	3.15	1.05	.0000	.0108	.0092	.0016	.21	.0130	.0000	.25	1.0
27637 July 5	Slight.	Slight.	.20	.26	Faintly vegetable.	Faintly vegetable.	3.40	1.40	.0000	.0150	.0126	.0024	.20	.0070	.0000	.37	1.0
27938 Aug. 1	V. slight.	V. slight.	.13	.20	Faintly vegetable.	Distinctly vegetable.	3.30	1.20	.0006	.0146	.0126	.0020	.24	.0060	.0000	.31	1.0
28417 Aug. 31	Slight.	V. slight.	.20	.26	Faintly vegetable.	Faintly vegetable.	3.80	1.55	.0000	.0162	.0154	.0008	.22	.0030	.0001	.37	1.1
28852 Oct. 3	Slight.	V. slight.	.21	.27	Very faintly vegetable.	Faintly vegetable.	3.70	1.45	.0006	.0168	.0160	.0008	.23	.0040	.0000	.38	0.8
29187 Oct. 31	Slight.	V. slight.	.24	.29	None.	Very faintly vegetable.	3.15	1.15	.0002	.0150	.0140	.0010	.24	.0030	.0000	.34	1.0
29503 Nov. 28	V. slight.	V. slight.	.13	.20	None.	None.	3.45	1.05	.0000	.0136	.0132	.0004	.22	.0070	.0000	.26	1.3
Av....	.....	.....	.23	.28	.....	.....	3.70	1.30	.0006	.0136	.0122	.0014	.24	.0137	.0001	.35	1.1

TABLE No. 29. — *Averages of Monthly Examinations of Water from Various Parts of the Metropolitan Water Works. — 1899.*

[Parts per 100,000.]

LOCALITY.	COLOR.		RESIDUE ON EVAPORATION.		AMMONIA.				NITROGEN AS		Oxygen Consumed.	Hardness.	
	Nessler Standard.	Platinum Standard.	Total.	Loss on Ignition.	Free.	ALBUMINOID.		Chlorine.	Nitrates.	Nitrites.			
						Total.	Dis- solved.						Sus- pended.
Quinepozet River, Holden,	.48	.45	3.65	1.69	.0028	.0261	.0206	.0055	.19	.0046	.0001	.60	0.5
Stullwater River, Sterling,	.31	.34	3.24	1.28	.0020	.0177	.0154	.0023	.17	.0050	.0000	.44	0.5
Nashua River, Clinton,	.30	.33	3.65	1.34	.0016	.0189	.0161	.0028	.20	.0053	.0001	.40	0.9
Walker's Brook, Marlborough,	.50	.46	14.87	3.85	.0719	.0518	.0330	.0158	1.80	.1248	.0046	.62	4.8
Sudbury Reservoir, surface,*	.19	.26	3.34	1.14	.0017	.0145	.0126	.0019	.20	.0063	.0001	.33	0.9
Sudbury Reservoir, mid-depth,*	.20	.26	3.09	1.28	.0036	.0139	.0125	.0014	.23	.0093	.0001	.33	1.1
Sudbury Reservoir, bottom,*	.21	.27	3.83	1.31	.0046	.0134	.0123	.0011	.24	.0112	.0001	.33	1.1
Framingham Reservoir No. 3, near dam,	.22	.27	3.59	1.28	.0015	.0152	.0131	.0021	.22	.0082	.0001	.35	1.1
Hopkinton Reservoir, influent,	.79	.62	5.55	2.45	.0030	.0392	.0274	.0028	.44	.0048	.0001	1.00	1.4
Hopkinton Reservoir, surface,	.36	.37	3.31	1.55	.0011	.0178	.0160	.0018	.28	.0041	.0000	.50	0.8
Hopkinton Reservoir, bottom,	.37	.37	3.27	1.43	.0022	.0163	.0141	.0022	.28	.0054	.0000	.50	0.7
Ashland Reservoir, influent,	.63	.54	4.22	1.89	.0012	.0224	.0207	.0017	.26	.0055	.0000	.73	1.1
Ashland Reservoir, surface,	.41	.40	3.12	1.45	.0007	.0189	.0168	.0021	.23	.0023	.0000	.53	0.6
Ashland Reservoir, bottom,	.43	.41	3.07	1.39	.0014	.0160	.0148	.0012	.24	.0042	.0000	.52	0.6
Framingham Reservoir No. 2, influent,	.45	.42	3.90	1.58	.0015	.0233	.0209	.0024	.28	.0052	.0000	.58	0.9
Framingham Reservoir No. 2, near dam,	.40	.39	3.39	1.48	.0006	.0194	.0173	.0021	.26	.0046	.0000	.53	0.7
Lake Cochituate, . . . . .	.22	.27	4.74	1.68	.0020	.0232	.0193	.0039	.43	.0090	.0001	.43	1.7
Terminal chamber, Sudbury Aqueduct,	.24	.29	3.77	1.40	.0021	.0143	.0132	.0011	.22	.0073	.0001	.35	1.1
Great Pond, . . . . .	.38	.38	5.65	1.83	.0066	.0262	.0199	.0063	.38	.0034	.0000	.44	2.1
Trap at State House, . . . . .	.23	.28	3.70	1.30	.0006	.0136	.0122	.0014	.24	.0137	.0001	.35	1.1

* These examinations were made weekly.

TABLE No. 30. — *Chemical Examinations of Water from a Faucet in Boston, from 1888 to 1899.*

[Parts per 100,000.]

YEAR.	COLOR.		RESIDUE ON EVAPORA- TION.		AMMONIA.				Chlorine.	NITROGEN AS		Oxygen Consumed.	Hardness.
	Nessler Standard.	Platinum Standard.	Total.	Loss on Ignition.	Free.	ALBUMINOID.				Nitrates.	Nitrites.		
						Total.	Dissolved.	Suspended.					
1888, . . .	.38	.38	4.94	1.53	.0012	.0215	-	-	.40	.0183	.0002	-	-
1889, . . .	.51	.46	4.71	1.43	.0005	.0199	.0176	.0023	.42	.0272	.0002	-	-
1890, . . .	.35	.36	4.70	1.25	.0003	.0169	.0148	.0021	.42	.0241	.0001	-	2.2
1891, . . .	.37	.38	4.39	1.63	.0005	.0161	.0136	.0025	.37	.0227	.0001	-	1.7
1892, . . .	.37	.37	4.70	1.67	.0007	.0168	.0188	.0030	.41	.0210	.0001	-	1.9
1893, . . .	.61	.53	4.54	1.84	.0010	.0174	.0147	.0027	.38	.0143	.0001	.60	1.8
1894, . . .	.69	.58	4.64	1.83	.0006	.0169	.0150	.0019	.41	.0106	.0001	.63	1.7
1895, . . .	.72	.59	4.90	2.02	.0006	.0197	.0175	.0022	.40	.0171	.0001	.69	0.7
1896, . . .	.49	.45	4.29	1.67	.0005	.0165	.0142	.0023	.37	.0155	.0001	.56	1.4
1897, . . .	.65	.55	4.82	1.84	.0009	.0193	.0177	.0016	.40	.0137	.0001	.64	1.6
1898, . . .	.41	.40	4.19	1.60	.0008	.0152	.0136	.0016	.29	.0097	.0001	.44	1.4
1899, . . .	.23	.28	3.70	1.30	.0006	.0136	.0122	.0014	.24	.0137	.0001	.35	1.1

TABLE No. 31. — *Microscopical Examinations of Water from Various Parts of the Metropolitan Water Works, 1899. (Means of Weekly Determinations.)**Nashua River at Head of Wachusett Aqueduct.*

[Standard units per cubic centimeter.]

MONTH.	ORGANISMS.	AMORPHOUS.	Principal Organisms.
	Surface.	Surface.	
January,	10	94	- -
February,	29	84	- -
March,	24	132	- -
April,	41	69	- -
May,	147	90	Rotifera. Infusoria.
June,	367	570	Infusoria. Rotifera. Diatomacæ. Chlorophycæ.
July,	327	274	Rotifera. Infusoria. Diatomacæ. Chlorophycæ.
August,	506	200	Infusoria. Diatomacæ. Rotifera. Chlorophycæ.
September,	212	246	Infusoria. Diatomacæ. Chlorophycæ.
October,	196	340	Diatomacæ. Infusoria. Chlorophycæ. Cyanophycæ.
November,	50	166	Infusoria. Diatomacæ.
December,	36	135	Diatomacæ.
Mean,	162	281	

TABLE No. 31 — *Continued.**Sudbury Reservoir, 1899.*

[Standard units per cubic centimeter.]

MONTH.	ORGANISMS.				AMORPHOUS.				Principal Organisms in the Reservoir.
	Surface.	Mid-depth.	Bottom.	End of Open Channel.	Surface.	Mid-depth.	Bottom.	End of Open Channel.	
January, . . .	17	22	20	17	123	131	149	114	-
February, . . .	65	19	19	11	69	88	101	78	Infusoria.
March, . . .	53	14	10	11	89	69	89	96	Infusoria.
April, . . .	166	79	42	57	92	94	124	124	Infusoria. Diatomaceæ.
May, . . .	385	141	110	163	82	83	96	148	Rotifera. Infusoria. Diatoma- ceæ. Chlorophyceæ.
June, . . .	1,281	580	236	411	88	117	120	377	Diatomaceæ. Cyanophyceæ. Chlorophyceæ. Rotifera.
July, . . .	1,028	718	534	495	105	130	145	242	Diatomaceæ. Cyanophyceæ. In- fusoria.
August, . . .	750	550	419	548	98	120	136	234	Diatomaceæ. Cyanophyceæ.
September, . . .	981	779	745	242	127	132	108	186	Infusoria. Cyanophyceæ. Dia- tomaceæ. Rotifera.
October, . . .	407	396	362	182	127	163	205	226	Cyanophyceæ. Diatomaceæ. In- fusoria. Chlorophyceæ.
November, . . .	290	252	357	40	123	148	161	141	Diatomaceæ. Infusoria. Cyano- phyceæ. Rotifera.
December, . . .	215	167	172	51	107	114	131	125	Diatomaceæ. Infusoria. Rotifera.
Mean, . . .	470	310	252	186	102	116	130	174	

Framingham Reservoir No. 3, 1899.

[Standard units per cubic centimeter.]

MONTH.	ORGANISMS.			AMORPHOUS.			Principal Organisms.
	Surface.	Mid-depth.	Bottom.	Surface.	Mid-depth.	Bottom.	
January,	27	40	100	118	139	181	-
February,	38	23	26	102	112	111	Diatomaceæ.
March,	34	46	41	102	87	84	Infusoria. Diatomaceæ.
April,	117	154	142	90	107	95	Infusoria. Diatomaceæ.
May,	1,188	1,049	562	121	127	142	Infusoria. Cyanophyceæ. Diatomaceæ. Rotifera.
June,	517	360	379	116	122	173	Diatomaceæ. Cyanophyceæ. Chlorophyceæ. Infusoria.
July,	1,120	925	738	146	167	163	Diatomaceæ. Cyanophyceæ. Chlorophyceæ. Rotifera.
August,	593	612	593	119	142	145	Diatomaceæ. Cyanophyceæ. Infusoria. Chlorophyceæ.
September,	448	506	446	162	165	185	Cyanophyceæ. Diatomaceæ. Infusoria. Chlorophyceæ.
October,	493	601	461	186	192	170	Cyanophyceæ. Diatomaceæ. Rotifera. Infusoria.
November,	401	443	163	141	150	151	Infusoria. Diatomaceæ. Ro- tifera. Chlorophyceæ.
December,	300	293	208	127	137	131	Rotifera. Diatomaceæ. In- fusoria.
Mean,	440	421	321	123	136	144	

TABLE NO. 31 — *Continued.**Whitehall Reservoir, 1899.*

[Standard units per cubic centimeter.]

MONTH.	ORGANISMS.	AMORPHOUS.	Principal Organisms.
	Surface.	Surface.	
January,	26	131	-
February,	46	123	Infusoria.
March,	498	127	Infusoria. Diatomaceæ.
April,	216	172	Rotifera.
May,	163	118	Infusoria. Diatomaceæ.
June,	214	135	Cyanophyceæ. Chlorophyceæ.
July,	1,096	180	Diatomaceæ. Infusoria.
August,	1,062	123	Cyanophyceæ. Chlorophyceæ.
September,	336	164	Diatomaceæ. Infusoria.
October,	163	190	Cyanophyceæ. Diatomaceæ.
November,	213	166	Chlorophyceæ. Infusoria.
December,	688	172	Cyanophyceæ. Diatomaceæ.
Mean,	393	150	Infusoria. Cyanophyceæ.

Hopkinton Reservoir, 1899.

[Standard units per cubic centimeter.]

MONTH.	ORGANISMS.				AMORPHOUS.				Principal Organisms in the Reservoir.
	Surface.	Mid-depth.	Bottom.	Inlet.	Surface.	Mid-depth.	Bottom.	Inlet.	
January,	251	181	204	14	125	128	130	79	Diatomaceæ. Rotifera.
February,	113	85	136	5	96	104	114	71	Infusoria. Cyanophyceæ.
March,	67	49	52	14	62	64	78	53	Diatomaceæ. Rotifera.
April,	64	59	30	42	66	68	65	68	Rotifera. Infusoria.
May,	619	166	56	129	89	89	100	82	Cyanophyceæ. Infusoria.
June,	1,736	530	295	126	88	103	104	106	Rotifera. Diatomaceæ.
July,	1,061	418	331	372	93	129	145	227	Cyanophyceæ. Infusoria.
August,	768	252	174	400	97	103	110	114	Diatomaceæ. Rotifera.
September,	831	450	428	650	110	114	119	145	Cyanophyceæ. Diatomaceæ.
October,	468	521	381	235	118	140	218	110	Infusoria. Rotifera.
November,	1,046	776	593	85	165	181	145	74	Cyanophyceæ. Infusoria.
December,	1,559	1,396	1,149	143	129	139	163	96	Diatomaceæ. Rotifera.
Mean,	715	407	319	185	103	114	124	102	Infusoria. Diatomaceæ.

TABLE No. 31 — *Continued.**Ashland Reservoir, 1899.*

[Standard units per cubic centimeter.]

MONTH.	ORGANISMS.				AMORPHOUS.				Principal Organisms in the Reservoir.
	Surface.	Mid-depth.	Bottom.	Inlet.	Surface.	Mid-depth.	Bottom.	Inlet.	
January, . . .	74	95	118	111	106	121	119	85	Diatomacæ.
February, . . .	105	119	65	10	94	97	115	85	Infusoria. Rotifera. Diatomacæ.
March, . . .	40	17	47	18	67	76	62	62	Infusoria.
April, . . .	48	35	32	39	63	67	80	71	Infusoria.
May, . . .	110	84	33	94	78	82	79	167	Diatomacæ. Infusoria.
June, . . .	888	277	102	35	107	88	104	124	Diatomacæ. Cyanophycæ.
July, . . .	537	233	109	45	104	118	108	102	Infusoria. Diatomacæ. Cyanophycæ.
August, . . .	777	548	222	43	105	114	93	95	Diatomacæ. Cyanophycæ.
September, . . .	760	830	463	304	84	91	107	239	Infusoria. Diatomacæ. Cyanophycæ.
October, . . .	524	477	361	127	158	166	184	116	Infusoria. Diatomacæ. Infusoria.
November, . . .	223	253	375	52	151	220	232	129	Rotifera. Chlorophycæ.
December, . . .	202	347	294	121	135	133	162	102	Diatomacæ. Infusoria. Rotifera. Chlorophycæ.
Mean, . . .	357	276	185	50	104	114	120	115	Chlorophycæ. Rotifera.

Framingham Reservoir No. 2, 1899.

[Standard units per cubic centimeter.]

MONTH.	ORGANISMS.				AMORPHOUS.				Principal Organisms in the Reservoir.
	Surface.	Mid-depth.	Bottom.	Inlet.	Surface.	Mid-depth.	Bottom.	Inlet.	
January, . . .	23	16	20	25	121	120	114	151	-
February, . . .	19	33	14	60	96	91	98	109	-
March, . . .	25	27	18	30	93	84	90	114	-
April, . . .	105	56	66	87	84	91	89	96	Infusoria. Diatomacæ.
May, . . .	90	53	49	103	106	108	131	128	Infusoria. Diatomacæ.
June, . . .	213	252	213	195	104	121	176	129	Chlorophycæ. Cyanophycæ.
July, . . .	472	506	477	1,065	151	167	206	173	Diatomacæ. Infusoria.
August, . . .	269	297	225	359	143	187	192	192	Cyanophycæ. Chlorophycæ.
September, . . .	262	238	196	308	157	132	138	143	Diatomacæ. Rotifera.
October, . . .	311	245	217	281	154	176	165	162	Diatomacæ. Cyanophycæ.
November, . . .	275	248	224	106	156	161	161	151	Infusoria. Chlorophycæ.
December, . . .	556	569	559	190	139	162	158	131	Cyanophycæ. Diatomacæ.
Mean, . . .	218	212	190	234	125	133	143	140	Infusoria. Rotifera. Diatomacæ. Chlorophycæ.

TABLE No. 31 — *Continued.**Lake Cochituate, opposite Gate-house, 1899.*

[Standard units per cubic centimeter.]

MONTH.	ORGANISMS.			AMORPHOUS.			Principal Organisms.
	Surface.	Mid-depth.	Bottom.	Surface.	Mid-depth.	Bottom.	
January, . .	980	777	701	161	147	308	Diatomaceæ. Cyanophyceæ. Infusoria.
February, . .	365	186	284	144	163	208	Diatomaceæ. Infusoria. Cyanophyceæ.
March, . .	111	89	244	82	116	216	Diatomaceæ. Infusoria.
April, . .	225	169	329	163	161	241	Diatomaceæ. Infusoria.
May, . .	1,990	469	475	101	186	192	Diatomaceæ. Cyanophyceæ. Infusoria. Chlorophyceæ.
June, . .	1,070	498	337	102	104	195	Diatomaceæ. Cyanophyceæ. Chlorophyceæ. Rotifera.
July, . .	352	333	583	92	101	438	Diatomaceæ. Infusoria. Chlorophyceæ. Infusoria.
August, . .	628	417	376	86	101	377	Cyanophyceæ. Diatomaceæ. Infusoria.
September, .	866	499	440	108	92	723	Cyanophyceæ. Diatomaceæ. Infusoria.
October, . .	1,051	621	586	148	163	714	Cyanophyceæ. Diatomaceæ. Infusoria. Chlorophyceæ.
November, .	989	1,101	1,384	167	205	560	Diatomaceæ. Cyanophyceæ. Infusoria. Crenothrix.
December, .	2,238	2,208	1,900	152	159	256	Diatomaceæ. Cyanophyceæ. Infusoria. Chlorophyceæ. Rotifera.
Mean, . .	905	614	644	125	141	369	

Chestnut Hill Reservoir, 1899.

[Standard units per cubic centimeter.]

MONTH.	ORGANISMS.				AMORPHOUS.				Principal Organisms in the Reservoir.
	Surface.	Mid-depth.	Bottom.	Inlet (Sudbury Aqueduct).	Surface.	Mid-depth.	Bottom.	Inlet (Sudbury Aqueduct).	
January, . .	-	-	-	38	-	-	-	140	-
February, . .	-	-	-	29	-	-	-	101	-
March, . .	-	-	-	29	-	-	-	81	-
April,* . .	165	145	134	141	83	92	104	98	Infusoria. Diatomaceæ.
May, . .	374	360	252	679	103	130	127	196	Diatomaceæ. Cyanophyceæ. Infusoria. Rotifera.
June, . .	355	222	157	412	107	118	119	168	Diatomaceæ. Infusoria. Chlorophyceæ. Cyanophyceæ.
July, . .	727	422	216	831	107	125	153	162	Diatomaceæ. Cyanophyceæ. Chlorophyceæ.
August, . .	677	552	203	651	114	139	363	192	Cyanophyceæ. Diatomaceæ. Infusoria. Chlorophyceæ.
September, .	618	402	469	567	139	139	848	208	Cyanophyceæ. Diatomaceæ. Infusoria. Chlorophyceæ.
October, . .	764	635	580	398	145	155	160	195	Cyanophyceæ. Diatomaceæ. Infusoria. Rotifera.
November, .	438	343	319	337	137	134	128	202	Infusoria. Cyanophyceæ. Diatomaceæ.
December, .	290	227	187	200	124	116	123	148	-
Mean, . .	490	256	280	359	118	128	236	158	

* Three weeks.

NOTE.—During August, September, October and November a small quantity of water was supplied to Chestnut Hill Reservoir through the Cochituate Aqueduct; this water contained an average of 992 organisms and 150 amorphous matter, in standard units per cubic centimeter.

TABLE No. 31 — *Continued.**Outlets from Chestnut Hill and Brookline Reservoirs and Taps in Boston, 1899.*

[Standard units per cubic centimeter.]

MONTH.	ORGANISMS.				AMORPHOUS.			
	Effluent Gate-house, Chestnut Hill Reservoir.	Gate-house, Brookline Reservoir.	Low-service Tap in Park Square, Boston.	High-service Tap in Mt. Vernon Street, Boston.	Effluent Gate-house, Chestnut Hill Reservoir.	Gate-house, Brookline Reservoir.	Low-service Tap in Park Square, Boston.	High-service Tap in Mt. Vernon Street, Boston.
January, . . .	83	69	75	53	133	127	127	124
February, . . .	21	29	12	28	99	99	104	83
March, . . .	22	46	27	16	84	87	82	84
April, . . .	137	168	112	137	100	117	100	99
May, . . .	318	162	113	176	109	90	85	92
June, . . .	284	172	178	198	120	108	122	129
July, . . .	553	446	372	364	105	118	122	131
August, . . .	579	599	355	344	132	118	130	154
September, . . .	653	312	405	277	140	139	137	160
October, . . .	648	295	268	368	180	134	109	167
November, . . .	509	247	238	288	138	135	110	158
December, . . .	141	149	153	160	120	116	115	142
Mean, . . .	329	224	192	201	122	116	112	127

Spot Pond, opposite Melrose Pumping Station, 1899.

[Standard units per cubic centimeter.]

MONTH.	ORGANISMS.			AMORPHOUS.			Principal Organisms.
	Surface.	Mid-depth.	Bottom.	Surface.	Mid-depth.	Bottom.	
January, . . .	90	124	137	128	172	215	Diatomacæ. Infusoria.
February, . . .	80	149	160	115	151	159	Diatomacæ. Infusoria.
March, . . .	74	92	121	122	150	140	Infusoria. Diatomacæ.
April, . . .	589	805	535	308	450	453	Infusoria. Diatomacæ.
May, . . .	1,256	1,514	1,092	351	447	452	Infusoria. Diatomacæ.
June, . . .	1,943	1,629	1,711	403	528	1,575	Infusoria. Cyanophycæ. Diatomacæ. Rotifera.
July, . . .	2,293	1,939	2,189	671	584	675	Cyanophycæ. Infusoria. Diatomacæ. Chlorophycæ.
August, . . .	2,383	2,428	1,729	490	582	675	Infusoria. Cyanophycæ. Diatomacæ. Chlorophycæ.
September, . . .	1,743	1,830	4,052	531	789	3,484	Diatomacæ. Cyanophycæ. Infusoria. Chlorophycæ.
October, . . .	2,244	2,387	3,231	448	485	828	Diatomacæ. Cyanophycæ. Infusoria. Rotifera.
November, . . .	712	651	916	462	531	1,296	Diatomacæ. Infusoria. Rotifera.
December, . . .	146	167	358	166	146	170	Diatomacæ. Infusoria. Chlorophycæ.
Mean, . . .	1,129	1,143	1,357	350	418	844	

Water from Spot Pond was not used for the supply of the Metropolitan District after April 24.

TABLE No. 31 — *Concluded.**Fells Reservoir, 1899.*

[Standard units per cubic centimeter.]

MONTH.	ORGANISMS.		AMORPHOUS.		Principal Organisms.	
	At Dam 3.	One-third Distance between Intake and Dam 3.	At Dam 3.	One-third Distance between Intake and Dam 3.		
January,	-	-	-	-	-	-
February,	-	-	-	-	-	-
March,	-	-	-	-	-	-
April,	-	-	-	-	-	-
May,	-	-	-	-	-	-
June,	-	-	-	-	-	-
July,	-	-	-	-	-	-
August,	-	-	-	-	-	-
September,	255	290	132	136	-	-
October,	103	86	112	102	-	-
November,	196	218	133	118	-	-
December,	168	209	164	144	-	-
Mean,	181	201	135	125	-	-

TABLE No. 32. — *Bacterial Examinations of Water from Various Parts of the Metropolitan Water Works, 1899. (Means of Weekly Determinations.)*

[Number of bacteria per cubic centimeter.]

MONTH.	CHESTNUT HILL RESERVOIR.					BROOKLINE RESERVOIR.	Tap in Park Square, Boston (Low Service).	Tap at No. 2 Mt. Vernon Street (High Service).
	Surface.	Mid-depth.	Bottom.	Inlet (Sudbury Aqueduct).	Effluent Gate-house.	Gate-house.		
January,	-	-	-	156	83	75	50*	67
February,	-	-	-	214	143	153	130	102
March,	-	-	-	298	194	283	161	180
April,	104	107	117	155	373	109	83	67
May,	240	283	372	750	520	125	199	146
June,	85†	84	170	112	790	104	169	170
July,	103	239	330	413	112	99	128	172
August,	105	140	176	75	138	87	153	211
September,	65	79	71	59	81	85	95	109
October,	63	55	81	66	67	99	61	103
November,	32	62	78	299	66	218	142	80
December,	32	34	37	92	35	74	56	69
Mean,	92	120	159	224	217	126	117	123

* One sample.

† Two samples.

Feeders of Lake Cochituate, 1899. (Means of Monthly Determinations.)

[Temperature in degrees Fahrenheit, organisms and amorphous matter in standard units per cubic centimeter, and bacteria in number per cubic centimeter.]

	Temperature.	Organisms.	Amorphous.	Bacteria.
Beaver Dam Brook,	53.8	2,335	181	647
Beaver Dam Brook (last culvert),	53.5	619	181	674
Course Brook,	53.9	154	110	422
Dug Pond,	54.4	771	153	198
Circular Dam, at south end of lake,	53.8	210	142	401
Pegan Brook,	54.4	160	233	5,743
Snake Brook,	54.5	112	408	1,341

TABLE No. 33. — *Colors of Water from Various Parts of the Metropolitan Water Works, 1899. (Means of Weekly Determinations.)*

[Platinum standard.]

MONTH.	NASHUA RIVER.	SUDBURY RESERVOIR.				FRAMINGHAM RESERVOIR No. 3.			WHITEHALL RESERVOIR.
	Surface.	Surface.	Mid-depth.	Bottom.	End of Open Channel.	Surface.	Mid-depth.	Bottom.	Surface.
January, . . . . .	.37	.39	.52	.55	.43	.49	.50	.51	.51
February, . . . . .	.33	.43	.47	.50	.37	.45	.46	.46	.69
March, . . . . .	.35	.35	.41	.45	.39	.38	.39	.40	.60
April, . . . . .	.33	.32	.36	.39	.48	.32	.33	.34	.48
May, . . . . .	.48	.30	.30	.31	.56	.31	.31	.31	.54
June, . . . . .	.51	.30	.30	.31	.55	.30	.30	.31	.64
July, . . . . .	.48	.26	.27	.29	.50	.28	.28	.29	.72
August, . . . . .	.40	.24	.26	.29	.44	.27	.29	.29	.76
September, . . . . .	.45	.25	.25	.26	.41	.28	.28	.28	.70
October, . . . . .	.46	.25	.26	.27	.47	.32	.32	.33	.74
November, . . . . .	.54	.30	.30	.30	.54	.34	.34	.35	.76
December, . . . . .	.43	.33	.33	.34	.45	.32	.32	.32	.72
Mean, . . . . .	.43	.31	.34	.36	.47	.34	.34	.35	.66

TABLE No. 33 — *Continued.*

[Platinum standard.]

MONTH.	HOPKINTON RESERVOIR.				ASHLAND RESERVOIR.				FRAMINGHAM RESERVOIR, No. 2.			
	Surface.	Mid-depth.	Bottom.	Inlet.	Surface.	Mid-depth.	Bottom.	Inlet.	Surface.	Mid-depth.	Bottom.	Inlet.
January, . . . . .	.67	.67	.67	.82	.68	.68	.67	.78	.59	.59	.61	.61
February, . . . . .	.69	.68	.68	1.02	.69	.69	.68	.72	.60	.60	.61	.62
March, . . . . .	.59	.62	.64	.61	.50	.64	.66	.61	.53	.54	.55	.53
April, . . . . .	.53	.54	.55	.90	.50	.52	.55	.81	.51	.51	.51	.58
May, . . . . .	.50	.50	.50	1.41	.54	.53	.51	1.35	.72	.72	.72	.88
June, . . . . .	.48	.48	.49	1.24	.52	.51	.50	.90	.65	.69	.72	.75
July, . . . . .	.38	.43	.43	.98	.44	.45	.46	.67	.62	.62	.63	.62
August, . . . . .	.32	.39	.40	.67	.40	.42	.45	.45	.61	.64	.67	.58
September, . . . . .	.31	.37	.38	.73	.37	.39	.44	.43	.48	.49	.51	.44
October, . . . . .	.35	.36	.41	.80	.39	.40	.45	.57	.39	.39	.39	.40
November, . . . . .	.39	.40	.45	.94	.48	.49	.50	.98	.39	.40	.40	.52
December, . . . . .	.38	.35	.36	.80	.46	.46	.47	.85	.38	.38	.39	.57
Mean, . . . . .	.47	.48	.50	.91	.50	.52	.53	.76	.54	.55	.56	.59

TABLE No. 33 — *Continued.*

[Platinum standard.]

MONTH.	FRAMINGHAM RESERVOIR No. 1.	LAKE COCHITUATE.				SPOT POND.		
	Surface.	Surface.	Mid-depth.	Bottom.	Influent Streams.*	Surface	Mid-depth.	Bottom.
January, . . . . .	.60	.45	.35	.55	.58	.44	.61	1.25
February, . . . . .	.60	.51	.41	.80	.58	.45	.74	1.27
March, . . . . .	.52	.48	.42	1.07	.49	.57	.79	1.19
April, . . . . .	.45	.43	.42	.61	.58	.64	.69	.72
May, . . . . .	.65	.33	.41	.50	.87	.67	.69	.71
June, . . . . .	.56	.29	.37	.89	.88	.61	.64	.75
July, . . . . .	.49	.25	.38	1.50	.73	.51	.51	.55
August, . . . . .	.40	.21	.34	1.62	.60	.46	.50	.54
September, . . . . .	.36	.21	.36	2.35	.53	.41	.45	.49
October, . . . . .	.40	.27	.45	2.86	.54	.37	.38	.40
November, . . . . .	.44	.39	.41	.85	.56	.50	.50	.52
December, . . . . .	.42	.36	.36	.42	.53	.41	.44	.47
Mean, . . . . .	.49	.35	.39	1.19	.62	.50	.58	.74

* The colors given in this column represent the combined colors of the water of the four principal feeders. The color of each is determined monthly, and due weight is given, in combining the results, to the sizes of the streams.

TABLE No. 33 — *Concluded.*

[Platinum standard.]

MONTH.	FELLS RESERVOIR.		CHESTNUT HILL RESERVOIR.					BROOKLINE RESERVOIR.	Tap in Park Square, Boston (Low Service).	Tap at No. 2 Mt. Vernon Street (High Service).
	Opposite In- lake (Sur- face).	Near Intake (Surface).	Surface.	Mid-depth.	Bottom.	Inlet (Sud- bury Aque- duct).	Effluent Gate-house.	Gate-house.		
January,	-	-	-	-	-	.51	.49	.49	.49	.49
February,	-	-	-	-	-	.46	.45	.45	.45	.45
March,	-	-	-	-	-	.40	.40	.39	.39	.39
April,	-	-	.30	.31	.31	.33	.31	.32	.31	.31
May,	-	-	.23	.29	.30	.31	.29	.28	.27	.27
June,	-	-	.30	.30	.30	.33	.30	.29	.30	.30
July,	-	-	.28	.29	.33	.32	.29	.29	.29	.30
August,	-	-	.23	.24	.79	.30	.23	.24	.23	.31
September, . . . . .	.27	.27	.24	.25	.64	.36	.24	.26	.23	.32
October, . . . . .	.29	.29	.27	.27	.27	.40	.27	.32	.27	.38
November, . . . . .	.31	.32	.30	.30	.30	.37	.30	.34	.31	.37
December, . . . . .	.24	.24	.24	.25	.26	.32	.26	.29	.26	.31
Mean, . . . . .	.23	.23	.27	.23	.39	.37	.32	.33	.32	.35

TABLE No. 34. — *Temperatures of Water from Various Parts of the Metropolitan Water Works, 1899. (Means of Weekly Determinations.)*

[The temperatures are taken at the same places and times as the samples for microscopical examination; the depth given for each reservoir is the depth from high-water mark where the temperatures are taken.]

[Degrees Fahrenheit.]

MONTH.	NASHUA RIVER.	SUDBURY RESERVOIR (DEPTH AT PLACE OF OBSERVATION 54.5 FEET).				FRAMINGHAM RESER- VOIR No. 3 (DEPTH AT PLACE OF OBSER- VATION 20.5 FEET).			HOPKINTON RESER- VOIR (DEPTH AT PLACE OF OBSERVA- TION 54.3 FEET).		
	Surface.	Surface.	Mid-depth.	Bottom.	End of Open Channel.	Surface.	Mid-depth.	Bottom.	Surface.	Mid-depth.	Bottom.
January, . . .	33.1	32.7	35.0	37.3	32.4	33.7	35.4	37.1	37.3	37.1	38.2
February, . . .	32.5	33.0	35.8	37.6	32.5	33.6	35.2	36.9	33.0	35.9	38.3
March, . . .	33.1	33.7	34.9	36.8	33.5	34.6	35.7	36.6	40.8	40.8	40.8
April, . . .	42.8	43.1	39.4	40.1	47.4	42.2	41.9	41.6	43.5	42.1	42.1
May, . . .	60.5	63.3	54.3	45.6	62.5	61.0	59.5	57.8	62.0	51.8	47.9
June, . . .	71.0	73.2	65.2	57.3	73.2	73.6	69.8	67.1	72.6	46.5	43.8
July, . . .	73.8	74.8	72.9	69.6	77.5	75.0	72.1	69.9	74.4	53.6	46.6
August, . . .	73.4	74.1	72.5	71.4	74.6	73.6	72.6	71.3	73.1	53.5	51.1
September, . .	65.3	67.4	67.1	67.0	66.1	67.1	66.2	65.4	66.8	58.5	50.6
October, . . .	54.5	57.0	56.4	56.0	54.8	54.6	54.1	53.4	56.8	56.5	51.4
November, . . .	41.1	45.0	44.9	44.6	40.7	42.9	43.4	44.0	44.2	44.7	45.3
December, . . .	36.4	36.9	37.1	37.1	37.4	36.8	37.3	38.0	35.6	37.8	38.8
Mean, . . .	51.5	52.9	51.3	50.0	52.7	52.4	51.9	51.6	53.3	46.6	44.6

TABLE No. 34 — *Continued.*

[Degrees Fahrenheit.]

MONTH.	ASHLAND RESERVOIR (DEPTH AT PLACE OF OBSERVATION 40.7 FEET).			FRAMINGHAM RESER- VOIR No. 2 (DEPTH AT PLACE OF OBSER- VATION 20.5 FEET).			LAKE COCHITUATE (DEPTH AT PLACE OF OBSERVATION 62.0 FEET).			WHITEHALL RESERVOIR.
	Surface.	Mid-depth.	Bottom.	Surface.	Mid-depth.	Bottom.	Surface.	Mid-depth.	Bottom.	Surface.
January, . . .	35.5	36.6	38.1	33.3	35.2	37.0	35.8	37.2	38.1	35.6
February, . . .	35.0	36.6	38.8	33.6	35.4	37.0	35.7	37.8	38.8	36.1
March, . . .	34.2	36.6	38.6	34.6	35.7	36.9	35.4	38.2	39.4	39.1
April, . . .	41.6	40.6	41.0	42.6	42.1	41.9	41.9	40.1	40.5	44.8
May, . . .	61.5	50.9	46.0	61.6	59.9	58.1	61.9	44.4	43.2	61.4
June, . . .	73.9	56.1	44.9	74.0	70.0	67.5	72.4	44.4	42.3	72.3
July, . . .	77.9	60.5	46.0	75.3	72.6	70.2	75.0	43.6	41.5	74.3
August, . . .	75.1	68.3	46.1	74.2	72.8	71.3	74.2	44.1	41.7	73.4
September, . .	67.8	67.4	50.6	67.2	66.3	65.3	66.7	45.1	42.5	64.8
October, . . .	55.7	55.3	52.4	56.0	55.5	54.8	56.2	45.6	42.9	54.3
November, . . .	41.5	41.6	41.9	42.9	43.3	44.0	45.5	45.4	43.1	41.8
December, . . .	36.9	37.9	38.8	36.7	37.3	37.8	39.4	39.2	39.2	37.3
Mean, . . .	53.1	49.0	43.6	52.7	52.2	51.8	53.3	42.1	41.1	52.9

TABLE No. 34 — *Concluded.*

[Degrees Fahrenheit.]

MONTH.	SPOT POND (DEPTH AT PLACE OF OBSERVATION 25.0 FEET).			CHESTNUT HILL RESERVOIR (DEPTH AT PLACE OF OBSERVATION 26.0 FEET).					BROOKLINE RESERVOIR.	Tap in Park Square, Boston (Low Service).	Tap at No. 2 Mt. Vernon Street (High Service).
	Surface.	Mid-depth.	Bottom.	Surface.	Mid-depth.	Bottom.	Inlet (Sudbury Aqueduct).	Effluent Gate-house.	Gate-house.		
January, . . .	36.3	38.8	39.3	-	-	-	35.6	35.4	36.4	36.5	37.4
February, . . .	35.9	38.5	39.1	-	-	-	35.6	35.3	35.8	36.1	37.1
March, . . .	35.8	39.0	39.8	-	-	-	35.7	36.1	36.0	37.1	38.7
April, . . .	43.3	46.1	46.1	44.8	44.7	44.4	41.5	42.9	42.4	42.3	43.1
May, . . .	58.8	58.7	57.8	59.0	58.0	49.0	57.6	58.2	59.7	57.7	58.0
June, . . .	72.1	70.6	69.4	70.1	68.4	51.7	66.5	69.1	71.0	67.4	67.8
July, . . .	73.5	73.4	73.1	74.3	72.8	53.5	72.5	73.5	74.0	71.1	71.8
August, . . .	75.0	74.0	73.2	73.4	72.7	55.8	72.9	73.1	73.4	73.0	72.3
September, . .	66.3	66.3	65.8	67.7	67.4	60.4	67.1	68.2	67.9	66.8	67.5
October, . . .	55.3	55.9	55.8	57.5	57.5	57.0	56.4	57.6	57.1	57.8	58.0
November, . . .	40.3	41.1	41.1	45.1	45.1	45.0	44.8	45.8	44.9	46.8	48.1
December, . . .	36.3	37.5	37.0	38.1	38.3	38.7	38.3	37.9	38.1	40.2	40.3
Mean, . . .	52.4	53.3	53.1	58.9	58.3	50.6	50.2	52.8	53.1	52.7	53.3

TABLE No. 35. — *Temperatures of the Air at Three Stations on the Metropolitan Water Works, 1899.*

[Degrees Fahrenheit.]

MONTH.	CHESTNUT HILL RESERVOIR.			FRAMINGHAM.			CLINTON.		
	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.	Maximum.	Minimum.	Mean.
January, . . .	53.0	-9.5	27.7	54.0	-10.0	26.4	62.0	-8.0	24.9
February, . . .	52.0	-7.0	24.1	49.0	-8.0	24.3	48.0	-9.0	21.8
March, . . .	62.5	14.0	33.0	60.0	14.0	33.3	57.0	11.0	29.9
April, . . .	84.0	25.5	47.6	82.0	24.0	47.6	80.0	20.0	45.7
May, . . .	90.0	31.0	58.5	89.0	33.0	58.6	88.0	31.0	58.3
June, . . .	95.5	49.0	70.8	95.0	48.0	70.2	91.0	41.0	69.0
July, . . .	95.0	48.0	72.5	93.0	45.0	71.6	89.0	45.0	70.4
August, . . .	92.5	44.5	69.2	95.0	43.0	69.2	88.0	45.0	67.7
September, . .	85.0	36.5	62.0	87.0	35.0	61.6	83.0	40.0	60.0
October, . . .	76.5	26.5	53.5	80.0	23.0	58.8	77.0	24.0	51.8
November, . . .	66.0	21.0	40.2	62.0	19.0	40.7	60.0	20.0	37.2
December, . . .	65.0	2.0	33.9	63.0	1.0	34.5	64.0	3.0	31.8
Average, . . .	-	-	49.4	-	-	49.3	-	-	47.4

TABLE No. 36. — *Table showing Length of Main Lines of Pipes and Connections owned and operated by Metropolitan Water Board and Number of Valves set in Same.*

	DIAMETER OF PIPES IN INCHES.												Totals.
	48	42	36	30	24	20	16	14	12	10	8	6	
Length owned and operated January 1, 1899 (feet),	121,537	8,075	44,533	27,050	31,202	38,049	51,941	26	12,721	353	745	758	336,990
Gate valves in same,	32	-	30	17	25	18	34	1	27	2	3	9	198
Air valves in same,	66	3	31	4	8	23	24	-	3	-	-	-	162
Length laid during 1899 (feet),	972	-	1,589	309	3,437	10,025	2,298	-	601	120	55	663	20,069
Gate valves in same,	-	-	5	2	2	5	7	-	10	3	1	7	42
Air valves in same,	2	-	2	-	4	6	6	-	-	-	-	-	20
Length abandoned during 1899 (feet),	52	-	12	-	232	4	413	-	300	-	-	553	1,566
Air valves in same,	-	-	-	-	-	-	3	-	-	-	-	-	3
Total length owned and operated January 1, 1900 (feet),	122,457	8,075	46,110	27,359	34,407	48,070	53,825	26	13,022	473	800	808	355,493*
Gate valves in same,	32	-	35	19	27	23	41	1	37	5	4	16	240
Air valves in same,	68	3	33	4	12	29	27	-	3	-	-	-	179

* 67.33 miles.

TABLE No. 37. — *Statement of Cast-iron Hydrant, Blow-off and Drain Pipes laid to January 1, 1900, owned and operated by Metropolitan Water Board.*

	DIAMETER OF PIPES IN INCHES.						Totals.
	24	16	12	8	6	4	
Length laid to January 1, 1899 (feet),	332	1,934	2,887	24	1,805	719	7,221
Length laid during 1899 (feet),	-	176	106	52	727	200	1,261
Total length in use January 1, 1900 (feet),	332	2,110	2,993	76	2,532	919	8,482
Valves set to January 1, 1899,	-	15	49	-	34	26	124
Valves set during 1899,	-	1	4	-	8	5	18
Total valves in use January 1, 1900,	-	16	53	-	42	31	142

TABLE No. 38. — *Length of Water Pipes, Four Inches in Diameter and Larger, in the Several Cities and Towns supplied by the Metropolitan Water Works.*

BY WHOM OWNED.	INCHES.																TOTAL.			
	48	42	40	36	30	28	24	20	18	16	14	12	10	8	7	6	5	4	Fect.	Miles.
Metropolitan Water Board.	122,457	5,075	-	46,110	27,359	-	34,407	48,070	-	53,826	26	13,022	473	800	-	868	-	-	355,493	67.33
Boston.	33,671	16,813	23,104	39,984	81,624	244	85,694	96,700	-	150,436	-	1,053,807	80,169	501,797	-	1,439,438	-	108,931	3,712,412	703.11
Somerville.	-	-	-	-	-	-	-	3,596	387	2,071	8,037	61,977	37,724	82,472	-	181,463	-	26,086	408,813	76.48
Malden.	-	-	-	-	-	-	-	-	707	-	13,023	58,865	18,952	61,617	-	186,747	-	112,675	452,586	85.71
Chelsea.	-	-	-	-	-	-	-	-	-	2,348	-	-	37,833	25,015	-	121,152	-	12,131	198,479	37.59
Quincy.	-	-	-	-	-	-	-	2,679	-	19,013	-	19,764	17,857	74,030	994	164,332	948	86,644	386,261	73.15
Everett.	-	-	-	-	-	-	2,484	2,900	-	2,233	206	5,570	26,897	16,756	-	103,115	-	47,033	209,194	39.62
Medford.	-	-	-	-	-	-	-	1,972	-	6,775	9,535	23,207	26,058	61,110	-	76,404	-	6,811	211,922	40.14
Melrose.	-	-	-	-	-	-	-	-	-	7,206	3,096	13,214	2,040	15,158	-	92,976	-	101,168	232,868	44.10
Revere.*	-	-	-	-	-	-	-	-	-	24,000	4,450	3,300	7,950	14,959	-	56,586	-	63,111	174,356	33.02
Watertown.	-	-	-	-	-	-	-	-	-	400	12,127	5,956	4,169	15,287	-	100,651	-	13,154	154,747	29.31
Winthrop.*	-	-	-	-	-	-	-	-	-	-	-	-	-	5,000	19,176	-	17,771	71,305	113,252	21.45
Beverly.	-	-	-	-	-	-	-	-	-	-	-	2,161	11,102	12,896	-	54,168	-	283	80,610	15.27
Beverly.	-	-	-	-	-	-	-	-	-	-	-	-	11,550	-	-	28,840	-	38,125	78,515	14.87
Andover.	-	-	-	-	-	-	-	-	-	-	-	27,644	19,612	21,301	-	65,440	-	36,723	170,720	32.33
Andover.	-	-	-	-	-	-	-	-	-	-	-	4,965	14,524	16,544	-	40,399	-	6,917	83,349	15.79
Andover.	-	-	-	-	-	-	-	-	-	-	-	1,293,455	321,910	939,918	994	2,752,350	948	731,097	7,018,567	-
Total, feet.	156,128	24,888	23,104	86,094	108,983	244	122,585	155,917	1,094	298,308	50,550	1,293,455	321,910	939,918	994	2,752,350	948	731,097	7,018,567	-
Total, miles.	29.57	4.71	4.38	16.30	20.64	.05	23.22	29.53	.21	50.82	9.57	244.97	60.97	178.01	.19	517.49	.18	138.46	1,329.27	-

* Pipes owned by Revere Water Company.

TABLE NO. 39. — *Number of Service Pipes, Meters and Fire Hydrants in the Several Cities and Towns supplied by the Metropolitan Water Works.*

CITY OR TOWN.	Services.	Meters.	Fire Hydrants.
Boston,	86,261	4,778	7,487
Somerville,	10,053	226	871
Malden,	6,912	2,967	387
Chelsea,	6,077	114	246
Quincy,	3,890	125	496
Everett,	4,264	25	346
Medford,	3,825	91	448
Melrose,	3,300	70	248
Revere,	1,881	11	105
Watertown,	1,530	1,214	266
Winthrop,	1,343	7	103
Belmont,	520	520	127
Nahant,	463	18	57
Arlington,	1,494	65	317
Swampscott,	912	-	112
Total,	132,730	10,231	11,616

APPENDIX No. 4.

SUMMARY OF STATISTICS.

REPORT FOR 1899.

The Metropolitan Water Works supply the Metropolitan Water District, which includes the following cities and towns:—

CITIES AND TOWNS.	Population, Census of 1896.	Estimated Population May 1, 1899.
Boston,	496,920	545,900
Somerville,	52,200	62,000
Chelsea,	31,264	33,800
Malden,*	29,708	36,000
Newton,†	27,590	32,300
Arlington,*	6,515	7,800
Quincy,	20,712	24,800
Everett,	18,573	24,400
Medford,*	14,474	18,100
Melrose,	11,965	14,900
Hyde Park,†	11,826	13,600
Watertown,	7,788	9,000
Revere,*	7,423	9,600
Winthrop,*	4,192	5,500
Belmont,	2,843	3,700
Nahant,*	865	900
Total population of Metropolitan Water District, . . .	744,858	842,300
Swampscott,*†	3,259	3,500

* Partially supplied from local sources. See Table No. 12, Appendix No. 3.

† No water supplied to these places during the year from Metropolitan Water Works.

‡ Swampscott is not in the Metropolitan Water District, but has been supplied with water from the Metropolitan Water Works.

Sources of Supply.

SOURCE.	Area of Watershed (Square Miles).	Remarks.
Lake Cochituate,	18.87	Works built by city of Boston in 1848.
Sudbury River,	75.20	Works built by city of Boston in 1872-78.
Naahua River,	118.23	Works begun in 1895; not finished.

Mode of Supply.

45.3 per cent. from gravity works.

54.7 per cent. from pumping works.

*Pumping.**Chestnut Hill High-service Station :—*

Builders of pumping machinery, Holly Manufacturing Company, Quintard Iron Works and E. P. Allis Company.

Description of coal used: Bituminous; George's Creek Cumberland, New River and Loyal Hanna. Price per gross ton in bins, \$3.53, \$3.48, \$3.45, \$3.58, \$3.67. Per cent. ash, 7.2.

	CHESTNUT HILL STATION.			
	Engines Nos. 1 and 2.	Engine No. 3 (Low Service).	Engine No. 3 (High Service).	Engine No. 4.
Coal consumed for year, in pounds, . . .	4,258,987	779,471	1,984,095	4,816,728
Cost of pumping figured on pumping-station expenses.	\$17,389.01	\$3,542.05	\$7,162.57	\$17,878.45
Total pumpage for year, million gallons, average dynamic head.	7,077.85	1,521.78	2,229.73	6,449.59
Gallons pumped per pound of coal, . . .	1,662	1,952	1,124	1,339
Duty, on basis of plunger displacement, .	62,290,000	81,480,000	116,560,000	137,930,000
Cost per million gallons raised to reservoir,	\$2.45	\$2.328	\$3.213	\$2.772
Cost per million gallons raised one foot, .	\$0.057	\$0.048	\$0.027	\$0.023

Consumption.

Estimated total population of the fifteen cities and towns supplied

wholly or partially during the year 1899,	802,800
Total consumption, gallons,	32,314,370,000
Furnished from Metropolitan Water Works sources, gallons,	31,807,090,000
Furnished from local sources, gallons,	507,280,000
Average daily consumption, gallons,	88,533,000
Gallons per day each inhabitant,	110

Distribution.

	Owned and Operated by Metropolitan Water Board.	Total Supplied by Metropolitan Water Works.
Kind of pipe used,	—*	—†
Sizes,	48 to 6 inch.	48 to 4 inch.
Extension less length abandoned, miles,	3.50	84.70
Length in use, miles,	67.33	1,329.27
Stop gates added,	60	—
Stop gates now in use,	382	—
Service pipes added,	—	7,162
Service pipes now in use,	—	182,730
Meters added,	—	746
Meters now in use,	—	10,231
Fire hydrants added,	—	762
Fire hydrants now in use,	—	11,616

* Cast iron and cement-lined wrought iron. † Cast iron, cement-lined wrought iron and kalamine.

APPENDIX No. 5.

RULES AND REGULATIONS FOR THE SANITARY PROTECTION OF WATERS USED
BY THE METROPOLITAN WATER BOARD FOR WATER SUPPLY.

Rules and Regulations of the State Board of Health, for the Sanitary Protection of Waters used by the Metropolitan Water Board for the Water Supply of any City, Town or Water Company under the Authority of Chapter 488 of the Acts of 1895, and Acts in Amendment thereof or Addition thereto, as adopted June 1, 1899.

The State Board of Health, acting under the authority of section 24 of chapter 488 of the Acts of the year 1895, hereby makes the following rules and regulations for the sanitary protection of all waters used by the Metropolitan Water Board for the water supply of any city, town or water company, under the authority of chapter 488 of the Acts of the year 1895, and acts in amendment thereof or addition thereto, which shall remain in force until further order, and which may be hereafter from time to time amended or added to by the State Board of Health:—

1. No cesspool, privy or other place for the reception, deposit or storage of human excrement, and no urinal or water-closet not discharging into a sewer, shall be located, constructed or maintained within fifty feet of high-water mark of any lake, pond, reservoir, stream, ditch, water course or other open waters, used by the Metropolitan Water Board as a source, or for the conveyance, storage or distribution, of the water supply of any city, town or water company, under the provisions of chapter 488 of the Acts of the year 1895, and acts in amendment thereof or addition thereto, or within fifty feet of high-water mark of any lake, pond, reservoir, stream, ditch, water course, or other open waters the water of which flows directly or ultimately into any waters so used by the Metropolitan Water Board.

2. No human excrement shall be deposited or discharged in or into any lake, pond, reservoir, stream, ditch, water course or other open waters, used by the Metropolitan Water Board as a source, or for the conveyance, storage or distribution, of the water supply of any city, town or water company, under the provisions of chapter 488 of the Acts of the year 1895, and acts in amendment thereof or addition thereto, or into any lake, pond, reservoir, stream, ditch, water course or other open waters, the water of which flows directly or ultimately into any waters so used by the Metropolitan Water Board; and no human excrement shall be kept in or deposited or

discharged in or into any cesspool, privy or other receptacle situated within two hundred and fifty feet of high-water mark of any open waters so used by the Metropolitan Water Board, or within two hundred and fifty feet of high-water mark of any open waters flowing as aforesaid into waters so used by the Metropolitan Water Board, unless such cesspool, privy or other receptacle is so constructed that no portion of its contents can escape or be washed into any such waters.

3. No human excrement, or compost containing human excrement, or contents of any privy or cesspool or sewer, or other receptacle for the reception or storage of human excrement, shall be deposited or discharged upon or into the ground at any place from which any such excrement, compost or contents, or particles thereof, may flow or be washed or carried into any lake, pond, reservoir, stream, ditch, water course or other open waters, used by the Metropolitan Water Board as a source, or for the conveyance, storage or distribution, of the water supply of any city, town or water company, under the provisions of chapter 488 of the Acts of the year 1895, and acts in amendment thereof or addition thereto, or into any lake, pond, reservoir, stream, ditch, water course or other open waters, the water of which flows directly or ultimately into any waters so used by the Metropolitan Water Board.

4. No house slops, sink waste, water which has been used for washing or cooking, or other polluted water, shall be discharged into any lake, pond, reservoir, stream, ditch, water course or other open waters, used by the Metropolitan Water Board as a source, or for the conveyance, storage or distribution, of the water supply of any city, town or water company, under the provisions of chapter 488 of the Acts of the year 1895, and acts in amendment thereof or addition thereto, or into any lake, pond, reservoir, stream, ditch, water course or other open waters, the water of which flows directly or ultimately into any waters so used by the Metropolitan Water Board; no house slops, sink waste, water which has been used for washing or cooking, or other polluted water, shall be discharged into the ground within fifty feet, or upon the ground within two hundred and fifty feet, of high-water mark of any open waters so used by the Metropolitan Water Board, or into the ground within fifty feet, or upon the ground within two hundred and fifty feet, of high-water mark of any open waters flowing as aforesaid into waters so used by the Metropolitan Water Board.

5. No garbage, manure or putrescible matter whatsoever shall be put into any lake, pond, reservoir, stream, ditch, water course or other open waters, used by the Metropolitan Water Board as a source, or for the conveyance, storage or distribution, of the water supply of any city, town or water company, under the provisions of chapter 488 of the Acts of the year 1895, and acts in amendment thereof or addition thereto, or into any lake, pond,

reservoir, stream, ditch, water course or other open waters, the water of which flows directly or ultimately into any waters so used by the Metropolitan Water Board; and no garbage, manure or putrescible matter whatsoever shall, except in the cultivation and use of the soil in the ordinary methods of agriculture, be put upon the ground within two hundred and fifty feet of high-water mark of any open waters so used by the Metropolitan Water Board, or within two hundred and fifty feet of high-water mark of any open waters flowing as aforesaid into waters so used by the Metropolitan Water Board.

6. No stable, pig-sty, hen-house, barn-yard, hog-yard, hitching or standing place for horses, cattle or other animals, or other place where animal manure is deposited or accumulates, shall be located, constructed or maintained, any part of which is within fifty feet of high-water mark of any lake, pond, reservoir, stream, ditch, water course or other open waters, used by the Metropolitan Water Board as a source, or for the conveyance, storage or distribution, of the water supply of any city, town or water company, under the provisions of chapter 488 of the Acts of the year 1895, and acts in amendment thereof or addition thereto, or within fifty feet of high-water mark of any lake, pond, reservoir, stream, ditch, water course or other open waters, the water of which flows directly or ultimately into any waters so used by the Metropolitan Water Board; and no stable or other place, as above enumerated, shall be located, constructed or maintained within two hundred and fifty feet of high-water mark of any open waters so used by the Metropolitan Water Board, or within two hundred and fifty feet of high water mark of any open waters flowing as aforesaid into waters so used by the Metropolitan Water Board, unless suitable and adequate provision is made to prevent any manure or other polluting matter from flowing or being washed into such open waters.

7. No interment shall, except by permission in writing by the Metropolitan Water Board, be made in any cemetery or other place of burial within fifty feet of high-water mark of any lake, pond, reservoir, stream, ditch, water course or other open waters, used by the Metropolitan Water Board as a source, or for the conveyance, storage or distribution, of the water supply of any city, town or water company, under the provisions of chapter 488 of the Acts of the year 1895, and acts in amendment thereof or addition thereto, or within fifty feet of high-water mark of any lake, pond, reservoir, stream, ditch, water course or other open waters, the water of which flows directly or ultimately into any waters so used by the Metropolitan Water Board.

8. No lands, which were not under the control of cemetery authorities and used for cemetery purposes on July 1, 1899, from which the natural drainage flows into any lake, pond, reservoir, stream, ditch, water course

or other open waters, used by the Metropolitan Water Board as a source, or for the conveyance, storage or distribution, of the water supply of any city, town or water company, under the provisions of chapter 488 of the Acts of the year 1895, and acts in amendment thereof or addition thereto, or into any lake, pond, reservoir, stream, ditch, water course or other open waters, the water of which flows directly or ultimately into any waters so used by the Metropolitan Water Board, shall be taken or used for cemetery purposes until a plan and description of the lands which it is proposed to use for such purposes, sufficient for their identification, shall be presented to the State Board of Health, and until such taking or use shall be approved in writing by the State Board of Health.

9. No manufacturing refuse or waste products or polluting liquid, or other substance of a nature poisonous or injurious either to human beings or animals, or other putrescible organic matter whatsoever, shall be discharged directly into, or at any place from which it may flow or be washed or carried into, any lake, pond, reservoir, stream, ditch, water course or other open waters, used by the Metropolitan Water Board as a source, or for the conveyance, storage or distribution, of the water supply of any city, town or water company, under the provisions of chapter 488 of the Acts of the year 1895, and acts in amendment thereof or addition thereto, or any lake, pond, reservoir, stream, ditch, water course or other open waters, the water of which flows directly or ultimately into any waters so used by the Metropolitan Water Board.

10. No system of sewers or other works for the collection, conveyance, disposal or purification of domestic or manufacturing sewage or drainage, or any other putrescible organic matter whatsoever, shall, except in accordance with plans first approved in writing by the State Board of Health, be constructed or maintained at any place within the watershed of any lake, pond, reservoir, stream, ditch, water course or other open waters used by the Metropolitan Water Board as a source, or for the conveyance, storage or distribution, of the water supply of any city, town or water company, under the provisions of chapter 488 of the Acts of the year 1895, and acts in amendment thereof or addition thereto. No private or separate sewer shall be constructed or maintained having an outlet upon or in the ground within two hundred and fifty feet of high-water mark of any open waters so used by the Metropolitan Water Board, or within two hundred and fifty feet of high-water mark of any lake, pond, reservoir, stream, ditch, water course or other open waters, the water of which flows directly or ultimately into any waters so used by the Metropolitan Water Board.

11. No public or private hospital, or other place intended for the reception or treatment of persons afflicted with a contagious or infectious disease, shall, until the location and construction thereof have been approved in

writing by the State Board of Health, be located or constructed at any place within the watershed of any lake, pond, reservoir, stream, ditch, water course or other open waters, used by the Metropolitan Water Board as a source, or for the conveyance, storage or distribution, of the water supply of any city, town or water company, under the provisions of chapter 488 of the Acts of the year 1895, and acts in amendment thereof or addition thereto. No public or private hospital, or other place intended for the reception or treatment of persons afflicted with a contagious or infectious disease, shall be maintained at any place within such watershed, unless all the provisions required by the State Board of Health for the purification or disposal of sewage, drainage or other polluting or organic matter, which may be discharged therefrom, have been complied with, and unless all orders issued from time to time by the State Board of Health in relation to the purification and disposal of sewage, drainage and other polluting or organic matter, which may be discharged therefrom, are fully complied with.

12. No tannery, currying shop or other establishment or place where the skins, wool, hair or fur of any animal are treated, shall, until the location and construction thereof have been approved in writing by the State Board of Health, be located or constructed at any place within the watershed of any lake, pond, reservoir, stream, ditch, water course or other open waters, used by the Metropolitan Water Board as a source, or for the conveyance, storage or distribution, of the water supply of any city, town or water company, under the provisions of chapter 488 of the Acts of the year 1895, and acts in amendment thereof or addition thereto. No tannery, currying shop or other establishment or place where the skins, wool, hair or fur of any animal are treated, shall be maintained at any place within such watershed, unless all the provisions required by the State Board of Health for the purification or disposal of sewage, drainage or other polluting or organic matter, which may be discharged therefrom, have been complied with, and unless all orders issued from time to time by the State Board of Health in relation to the purification and disposal of sewage, drainage and other polluting or organic matter, which may be discharged therefrom, are fully complied with.

13. No slaughter house or other building for carrying on the business of slaughtering cattle, sheep or other animals, and no melting or rendering establishment, shall, until the location and construction thereof have been approved in writing by the State Board of Health, be located or constructed at any place within the watershed of any lake, pond, reservoir, stream, ditch, water course or other open waters, used by the Metropolitan Water Board as a source, or for the conveyance, storage or distribution, of the water supply of any city, town or water company, under the provisions of chapter 488 of the Acts of the year 1895, and acts in amendment thereof

or addition thereto. No slaughter house or other building for carrying on the business of slaughtering cattle, sheep or other animals, and no melting or rendering establishment, shall be maintained at any place within such watershed, unless all the provisions required by the State Board of Health for the purification or disposal of sewage, drainage or other polluting or organic matter, which may be discharged therefrom, have been complied with, and unless all orders issued from time to time by the State Board of Health in relation to the purification and disposal of sewage, drainage and other polluting or organic matter, which may be discharged therefrom, are fully complied with.

14. No person shall bathe in, and no person shall, unless permitted by a special regulation or by a written permit of the Metropolitan Water Board, fish in, or send, drive or put any animal into, the Wachusett Reservoir, so called, the open channel of the Wachusett Aqueduct, Sudbury Reservoir, Hopkinton Reservoir, Ashland Reservoir, Farm Pond, Whitehall Reservoir, Framingham Reservoir No. 1, Framingham Reservoir No. 2, Framingham Reservoir No. 3, Lake Cochituate, Spot Pond, Chestnut Hill Reservoir, or any other lake, pond, reservoir or stream used by the Metropolitan Water Board as a source, or for the conveyance, storage or distribution, of the water supply of any city, town or water company, under the provisions of chapter 488 of the Acts of the year 1895, and acts in amendment thereof or addition thereto. No persons other than a member of the said Metropolitan Water Board, its officers, agents or employes, or public officers whose duties may so require, shall, unless so permitted by regulation or permit of the said Board, enter or go, in any boat, skiff, raft or other contrivance, on or upon the water of any of said reservoirs, or said lake, ponds or open channel, or of other such lakes, ponds or reservoirs, nor shall enter or go upon, or drive any animal upon the ice of, any of said waters or other such lakes, ponds, reservoirs or streams.

15. No person shall enter upon the Wachusett Reservoir, so called, Sudbury Reservoir, the open channel of the Wachusett Aqueduct, Hopkinton Reservoir, Ashland Reservoir, Framingham Reservoir No. 1, Framingham Reservoir No. 2, Framingham Reservoir No. 3, Farm Pond, Whitehall Reservoir, Lake Cochituate, Spot Pond, Chestnut Hill Reservoir, or any other lake, pond or reservoir used by the Metropolitan Water Board as a source, or for the conveyance, storage or distribution, of the water supply of any city, town or water company, under the provisions of chapter 488 of the Acts of the year 1895, and acts in amendment thereof or addition thereto, for the purpose of cutting or taking ice, or cut or take ice from any such lake, pond or reservoir, without a written permit, signed by the Metropolitan Water Board, stating the time and place for which such permission is given.

16. All reports which may be made to any board of health, or to any

health officer of any city or town, of cases of contagious or infectious diseases occurring within the watershed of any lake, pond, reservoir, stream, ditch, water course or other open waters, used by the Metropolitan Water Board as a source, or for the conveyance, storage or distribution, of the water supply of any city, town or water company, under the provisions of chapter 488 of the Acts of the year 1895, and acts in amendment thereof or addition thereto, shall be open to the inspection at all reasonable times of the Metropolitan Water Board, its officers or agents.

17. Nothing contained in these rules shall prevent the Metropolitan Water Board from making or enforcing such further rules, regulations and orders, not inconsistent with these rules, as it may deem necessary for carrying out the provisions of chapter 488 of the Acts of the year 1895, and acts amendatory thereof and additional thereto.

By order of the Board,

(Signed)

SAMUEL W. ABBOTT,

Secretary.

[The foregoing were adopted by the Metropolitan Water Board on June 30, 1899.]

Special Regulations of the Metropolitan Water Board.

The following special regulations were made by the Metropolitan Water Board on June 30, 1899, under and pursuant to Rule 14 of the rules made by the State Board of Health on June 1, 1899, for the sanitary protection of waters used by the Metropolitan Water Board for the water supply of the cities and towns of the Metropolitan Water District under the authority of chapter 488 of the Acts of the year 1895, and also under and pursuant to the general powers and authority given to the Metropolitan Water Board by said chapter.

I.

Permission is given, until further order, to fish and boat in and upon the waters of Lake Cochituate, Farm Pond and Whitehall Reservoir, subject to the following limitations and conditions:—

a. No fish, food or other matter tending to pollute the water shall be thrown into the water or left upon the shores.

b. No tin cans or bait boxes shall be thrown into the water or left upon the shores.

c. No person shall build any fire upon the shores or other land belonging to the Commonwealth.

d. Care shall be taken not to disturb the gravel or stone protection around the shores.

e. In case fishing is carried on through the ice, no person shall throw or leave upon the ice any fish, bait, food or other matter tending to pollute the water.

II.

Permission is given, until December 1, 1899, or until otherwise ordered, to fish in the waters of Spot Pond, subject to the following limitations and conditions :—

a. No fish, food or other matter tending to pollute the water shall be thrown into the water or left upon the shores.

b. No tin cans or bait boxes shall be thrown into the water or left upon the shores.

c. No person shall build any fire upon the shores or other land belonging to the Commonwealth.

d. Care shall be taken not to disturb the gravel or stone protection around the shores.

III.

Permission is given, until further order, to fish in the waters of Sandy Pond and in the South Branch of the Nashua River, above the temporary dam of the Metropolitan Water Board in Clinton, subject to the following limitations and conditions :—

a. No fish, food or other matter tending to pollute the water shall be thrown into the water or left upon the shores.

b. No tin cans or bait boxes shall be thrown into the water or left upon the shores.

c. No person shall build any fire upon the shores or other land belonging to the Commonwealth.

d. Care shall be taken not to disturb the gravel or stone protection around the shores.

e. In case fishing is carried on through the ice, no person shall throw or leave upon the ice any fish, bait, food or other matter tending to pollute the water.

IV.

Permission is given, until further order, to fish from the highway and to enter from the highway and fish through the ice, in the waters of the open channel of the Wachusett Aqueduct, Sudbury Reservoir, Framingham Reservoir No. 1, Framingham Reservoir No. 2, Hopkinton Reservoir and Ashland Reservoir, subject to the following limitations and conditions :—

a. No fish, food or other matter tending to pollute the water shall be thrown into the water or left upon the shores.

b. No tin cans or bait boxes shall be thrown into the water or left upon the shores.

c. No person shall build any fire upon the shores or other land belonging to the Commonwealth.

d. Care shall be taken not to disturb the gravel or stone protection around the shores.

e. In case fishing is carried on through the ice, no person shall throw or leave upon the ice any fish, bait, food or other matter tending to pollute the water.

f. No permission is given to fish from the shores at places other than the highway.

V.

Special permits, for limited periods, may be issued by the secretary of the Board, giving the holders thereof permission to fish in Hopkinton Reservoir and in Ashland Reservoir, from the shores but not from the dam, and to fish through the ice. All such permits to fish shall be subject to the following limitations and conditions:—

a. Fishing shall be carried on only in such places and for such period of time as shall be stated in the permit.

b. No fish, food or other matter tending to pollute the water shall be thrown into the water or left upon the shores.

c. No tin cans or bait boxes shall be thrown into the water or left upon the shores.

d. No person shall build any fire upon the shores or other land belonging to the Commonwealth.

e. Care shall be taken not to disturb the gravel or stone protection around the shores.

f. In case fishing is carried on through the ice, no person shall throw or leave upon the ice any fish, bait, food or other matter tending to pollute the water.

g. A person having a special permit shall exhibit his permit when called upon to do so by any agent or employé of the Metropolitan Water Board.

h. This permission to fish is forfeited and revoked by any violation of the above-named limitations and conditions, or by its use by any other person than the one to whom it is given as named upon its face.

VI.

Special permits, for limited periods, may be issued by the secretary of the Board, giving the holders thereof permission to fish in Sudbury Reservoir, subject to the limitations and conditions hereinafter named, through the ice or from the following designated places on the shores of the reservoir:—

(1) The point of land lying partly in the city of Marlborough and partly in the town of Southborough, on the westerly shore of the reservoir, between posts marked "1" and "2," being land formerly belonging to Julia A. Ward, Henry H. Morse, Lucius H. Horne, Lucy N. Fox, Angeline H. Morse and Dennis Sweeney.

(2) The point of land situated in the city of Marlborough, on the northerly shore of the reservoir, between posts marked "3" and "4," being land formerly belonging to William Barnes.

(3) The point of land situated in the city of Marlborough, on the northerly shore of the reservoir, between posts marked "5" and "6," being land formerly belonging to Hartwell Howe and the heirs of Stephen A. Howe.

(4) The point of land situated in the city of Marlborough, near the Southborough line, on the easterly shore of the reservoir, between posts marked "7" and "8," being land formerly belonging to Hartwell Howe and the heirs of Stephen A. Howe.

(5) The tract of land situated in the town of Southborough, on the easterly shore of the reservoir, at the narrows separating the larger part of the reservoir from the portion near the dam, beginning at post marked "9" at land formerly owned by William B. Rice and extending to post marked "10" at land formerly belonging to Horace Nichols.

(6) The point of land situated in the town of Southborough, on the southerly shore of the reservoir, and north of the old Rice Mill Road, between posts marked "11" and "12," being land formerly belonging to Mary J. Robertson, Edgar A. Lamphrey and Susan H. Lamphrey.

(7) The tract of land situated in the town of Southborough, on the westerly shore of the reservoir, lying on both sides of the discontinued road formerly known as the Williams Mill Road, and near the Willow Bridge Road, so called, between points marked "13" and "14," being land formerly belonging to Mrs. Sarah F. Williams and the heirs of Warren Parmenter.

All such permits to fish shall be subject to the following limitations and conditions : —

a. Fishing shall be carried on only in such places and for such period of time as shall be stated in the permit.

b. No fish, food or other matter tending to pollute the water shall be thrown into the water or left upon the shores.

c. No tin cans or bait boxes shall be thrown into the water or left upon the shores.

d. No person shall build any fire upon the shores or other land belonging to the Commonwealth.

e. Care shall be taken not to disturb the gravel or stone protection around the shores.

f. In case fishing is carried on through the ice, no person shall throw or leave upon the ice any fish, bait, food or other matter tending to pollute the water.

g. A person having a special permit shall exhibit his permit when called upon to do so by any agent or employé of the Metropolitan Water Board.

h. This permission to fish is forfeited and revoked by any violation of the above-named limitations and conditions, or by its use by any other person than the one to whom it is given as named upon its face.

VII.

Special permits may be issued by the secretary of the Board to owners of lands adjoining the margins of Framingham Reservoir No. 1 and Framingham Reservoir No. 2, to fish from the shores opposite their respective estates. All such permits to fish shall be subject to the following limitations and conditions: —

a. Fishing shall be carried on only in such places and for such periods of time as shall be stated in the permit.

b. No fish, food or other matter tending to pollute the water shall be thrown into the water or left upon the shores.

c. No tin cans or bait boxes shall be thrown into the water or left upon the shores.

d. No person shall build any fire upon the shores or other land belonging to the Commonwealth.

e. Care shall be taken not to disturb the gravel or stone protection around the shores.

f. In case fishing is carried on through the ice, no person shall throw or leave upon the ice any fish, bait, food or other matter tending to pollute the water.

g. A person having a special permit shall exhibit his permit when called upon to do so by any agent or employé of the Metropolitan Water Board.

h. This permission to fish is forfeited and revoked by any violation of the above-named limitations and conditions, or by its use by any other person than the one to whom it is given as named upon its face.

APPENDIX No. 6.

LEGISLATION OF THE YEAR 1899 AFFECTING THE
METROPOLITAN WATER BOARD.

[Chapter 195 of the Acts of the Year 1899.]

AN ACT TO AUTHORIZE THE CITY OF SOMERVILLE TO LAY OUT AND
MAINTAIN A PARKWAY.*Be it enacted, etc., as follows :*

SECTION 1. The city of Somerville by its city council may at any time within three years after the passage of this act take from time to time in fee or otherwise, any lands and rights in lands within the limits of said city, upon such terms and conditions as said city council may deem advisable, by gift or purchase, or by right of eminent domain or otherwise, and hold the same in fee or otherwise, and maintain them for the purpose of a parkway or boulevard. Said parkway or boulevard may extend from Nathan Tuft's park, at the junction of Broadway and Elm streets in Somerville, by such route and courses and of such width and to such part of the boundary line of said city on Mystic river or Alewife brook as said city council may determine.

City of Somerville may take lands, etc., for a parkway.

SECTION 2. Said city council shall have power to lay out and improve said parkway, to make rules for the use and government thereof, and to fix penalties for breaches of such rules, not exceeding twenty dollars for each offence ; and to exercise all other powers in relation thereto which are given to boards of park commissioners constituted under chapter one hundred and fifty-four of the acts of the year eighteen hundred and eighty-two by said chapter, by chapter three hundred and thirteen of the acts of the year eighteen hundred and ninety-six, and by all other acts relating to the authority of such boards.

May lay out and improve parkway, make rules, etc.

SECTION 3. Said city council may make agreements with the metropolitan park commission, the metropolitan water board, the board of metropolitan sewerage commissioners, the city of Boston, or with any officer or board of said city of Boston having the care or control of any lands, rights, easements or interests in lands within the limits of said parkway, for the care and

Care and control of parkway, etc.

control, including police protection, and disposition of said lands, rights, easements and interests in lands, for such period and upon such terms and conditions as the parties to such agreements may deem expedient. Said city council may from time to time make agreements with the metropolitan park commission for the care and control, including police protection, of the whole or any part of said parkway. Conveyance of said parkway, lands, rights, easements and interests in lands may be made in accordance with any agreements made as authorized by this section.

Description of
lands, etc., to
be recorded.

SECTION 4. Within sixty days after the taking of any lands or rights in lands as aforesaid, otherwise than by purchase or gift, said city shall cause to be recorded in the registry of deeds for the southern district of the county of Middlesex a description thereof sufficiently accurate for identification, with a statement of the purpose for which the same were taken, which statement shall be signed by the mayor of said city. The title to all lands and rights in lands so taken shall vest in the city of Somerville as provided in section one of this act.

Damages.

SECTION 5. Said city of Somerville shall pay all damages sustained by any person or corporation by the taking of any lands or rights in lands, or by any other thing done by said city under the authority of this act. Any person or corporation sustaining damages as aforesaid, who fails to agree with said city as to the amount of damages so sustained, may have the damages determined in the manner provided by law when land is taken for the laying out of highways, on application at any time within two years from the taking of such land or other property or the doing of any other injury under the authority of this act.

Assessment of
betterments.

SECTION 6. At any time within five years after the first taking of lands or rights in lands for said parkway has been made, whether or not the same is then fully constructed, said city council shall have the same authority to determine the value of, and to assess upon real estate, the betterments accruing to said real estate by such takings and by the laying out and construction of a parkway under this act, so far as the same at the time of said assessment has been constructed, that is conferred by chapter fifty-one of the Public Statutes upon boards of city or town officers authorized to lay out streets or ways; and the provisions of the first eight sections of said chapter fifty-one shall apply to such assessments by said city council, except as to the time and manner of making said assessments, as hereinbefore provided.

SECTION 7. This act shall take effect upon its acceptance by a majority vote of each branch of the city council of said city, taken by yeas and nays. *[Approved March 28, 1899.]* When to take effect.

[Chapter 270 of the Acts of the Year 1899.]

AN ACT RELATIVE TO WATER COURSES AND DRAINS IN THE CITY
OF MARLBOROUGH.

Be it enacted, etc., as follows:

SECTION 1. The city of Marlborough, for drainage purposes or for the protection of the public health, may by its board of aldermen, acting within the limits of the city, from time to time, improve the brooks and natural streams flowing in said city or any part thereof, by widening the same, removing obstructions in or over them, diverting the water, altering the courses or deepening the channels thereof, and may conduct any surface or ground water into the same, and the more effectually to make said improvements the said city may, by vote of the city council, purchase or take land in fee simple or otherwise on either side of the present channels of any such brooks or natural streams, or may in the same manner purchase or take land in fee simple or otherwise to form new channels into which said waters or any surface or ground water may be diverted within the limits of said city: *provided, however,* that nothing herein shall authorize the taking by the city of Marlborough of land heretofore taken by the metropolitan water board for the metropolitan water supply. May improve brooks, take land, etc., for drainage purposes, etc.

SECTION 2. When land is taken by virtue of the preceding section the proceedings shall be the same as in the laying out of highways or streets in said city. Proviso. Proceedings when land is taken.

SECTION 3. Damages occasioned by the making of said improvements shall be ascertained and recovered as in the laying out of highways or streets in said city. Damages.

SECTION 4. At any time within two years after any brook or natural stream in said city is improved in any of the ways mentioned in the first section of this act, under an order declaring the same to be done under the provisions of law authorizing the assessment of betterments, if in the opinion of the board of aldermen of said city any real estate in said city, including that, if any, of which a part is taken therefor, receives any benefit or advantage therefrom beyond the general advantages to all real estate in said city, the board may determine the value of said benefit and advantage to such real estate, and may assess upon the same a proportionate share of the expense of making such Assessment and collection of betterments.

improvement; but no such assessment shall exceed one half of such adjudged benefit and advantage, nor shall the same be made until the work of making such improvement is completed. All laws now or hereafter in force in relation to the assessment and collection of betterments in the case of the laying out, altering, widening, grading or discontinuing of ways in said city shall, so far as the same are applicable and not inconsistent with the provisions of this act, apply to the doings of the board of aldermen under this act; and all persons who are aggrieved by the assessment of betterments under the provisions of this act shall have the same remedies which now are or may hereafter be provided by law for persons aggrieved by the assessment or levy of betterments in the laying out of ways in said city.

Penalty for injury to drainage work, pollution of water, etc.

SECTION 5. No person shall destroy or injure any drainage or sewerage work of said city, or without lawful authority pollute any natural water course in said city, or put or maintain any obstruction therein; and whoever violates any provision of this section shall for each offence be punished by a fine not exceeding five hundred dollars or by imprisonment in the house of correction not exceeding three months, or by both such fine and imprisonment.

SECTION 6. This act shall take effect upon its passage.
[Approved April 14, 1899.]

[Chapter 274 of the Acts of the Year 1899.]

AN ACT TO PLACE THE CHESTNUT HILL RESERVOIR GROUNDS UNDER THE CUSTODY OF THE BOARD OF PARK COMMISSIONERS OF THE CITY OF BOSTON.

Be it enacted, etc., as follows:

Park commissioners of Boston to have care and control of certain lands.

SECTION 1. The board of park commissioners of the city of Boston shall have the custody, care and control of all lands owned by the city of Boston in the territory bounded east by Chestnut Hill avenue, south by the boundary line between the town of Brookline and the city of Boston, west by the boundary line between the city of Newton and the city of Boston, and north by Commonwealth avenue and South street; may take by purchase or otherwise such other lands within said boundary not owned by the Commonwealth, as said board with the approval of the mayor may deem desirable for park purposes; and may assume the custody, care and control of all lands within said boundary now owned by the Commonwealth which the metropolitan water board and said board of park commissioners of the city of Boston, with the approval of the mayor, may deem

May take certain lands, etc.

desirable for said purposes. Said board of park commissioners shall have the same powers over any lands placed or taken under the custody, care and control of said board by authority of this act, as if said lands had been taken by said board by the exercise of the right of eminent domain, given by chapter one hundred and eighty-five of the acts of the year eighteen hundred and seventy-five and acts in amendment thereof or in addition thereto.

SECTION 2. The treasurer of said city, to pay the expenses incurred in the taking of any lands under authority of this act, may from time to time, at the request of said board, approved by the mayor, issue bonds of said city to a total amount not exceeding one hundred and fifty thousand dollars.

Payment of expenses.

SECTION 3. Said board of park commissioners when authorized by the city council may sell any lands owned by the city, within the boundaries aforesaid, on such terms as said board with the approval of the mayor may deem proper, and shall use the proceeds thereof in payment for any lands taken for park purposes under this act.

Certain lands may be sold.

SECTION 4. This act shall take effect upon its passage.
[Approved April 15, 1899.]

[Chapter 306 of the Acts of the Year 1899.]

AN ACT RELATIVE TO CERTAIN SUITS FOR DAMAGES FOR PROPERTY TAKEN BY THE METROPOLITAN WATER BOARD.

Be it enacted, etc., as follows:

SECTION 1. In any case where the lands, ponds, reservoirs, water sources, aqueducts or other property of any city or town, taken or used by the Commonwealth under authority of chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five, are situated in more than one county, all petitions for damages authorized by said act which are now pending, or which may hereafter be brought, including petitions for damages caused by cancellation of the contracts mentioned in section seven of said statute, shall be consolidated and entered as one petition in the office of the clerk of the superior court for the county of Norfolk, and the superior court for said county shall have exclusive jurisdiction thereof.

Petitions for damages for property taken by the metropolitan water board.

SECTION 2. In all such cases the court, upon application of either party, shall appoint three commissioners, who shall hear the parties and their evidence and make report of their findings to the court, and the findings of fact in such report shall be prima facie evidence thereof in any jury trial claimed as pro-

Commissioners to determine damages, appointment, duties, etc.

vided by statute. Said commissioners shall, at the request of either party, report their rulings upon all matters of law arising upon the hearing before them. Upon the return of the report the court may, at the request of either party, report for the determination of the supreme judicial court such questions of law presented by the report of the commissioners as either party may designate; and thereupon, in case the rulings of the commissioners on such questions of law shall be rejected or modified by the supreme judicial court, the case shall be remanded to the commissioners who shall, after hearing the arguments of the parties, file a final report determining and awarding damages sustained by the city or town, as aforesaid, in conformity with the opinion of the supreme judicial court upon such questions of law. If either party shall be dissatisfied with the amount of damages thus awarded by the commissioners such party may, within thirty days after the return of the final report of the commissioners, file a notice in writing claiming a jury trial; and thereupon the damages sustained by the city or town shall be determined by a jury in the superior court for said county. The expense of said hearings for stenography, printing and compensation of the commissioners shall be paid equally by the parties to the proceeding.

Damages may be determined by a jury in certain cases, etc.

SECTION 3. This act shall take effect upon its passage.
[Approved April 27, 1899.]

[Chapter 308 of the Acts of the Year 1899.]

AN ACT RELATIVE TO ORDERS, RULES AND REGULATIONS MADE BY THE STATE BOARD OF HEALTH OR BY THE METROPOLITAN WATER BOARD.

Be it enacted, etc., as follows:

Publication of certain orders, rules, etc., to be deemed legal notice.

SECTION 1. The publication of any order, rule or regulation made by the state board of health, under authority of chapter five hundred and ten of the acts of the year eighteen hundred and ninety-seven, for the purpose of preventing the pollution and securing the sanitary protection of the waters and tributaries named therein used as sources of water supply, or the publication of any order, rule or regulation made either by the metropolitan water board or by the state board of health for the sanitary protection of the waters used by the metropolitan water board for the water supply of any city, town or water company, under the provisions of chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five, in a newspaper of the city or town in which such order, rule or regu-

lation is to take effect, shall be deemed legal notice to all persons. If no newspaper is published in the city or town in which any such order, rule or regulation is to take effect, the posting of a copy thereof in some public place in said city or town shall be deemed legal notice to all persons.

SECTION 2. The affidavit of a person causing a notice to be so published or posted, being filed and recorded, with a copy of the notice, in the office of the clerk of any city or town in which any such order, rule or regulation is to take effect, shall be deemed evidence of the time, place and manner in which the notice was given. Evidence of notice.

SECTION 3. This act shall take effect upon its passage.
[Approved April 27, 1899.]

[Chapter 342 of the Acts of the Year 1899.]

AN ACT TO EXTEND THE TIME WITHIN WHICH PETITIONS MAY BE FILED FOR DAMAGES SUSTAINED BY THE TAKING OF REAL ESTATE FOR THE METROPOLITAN WATER WORKS.

Be it enacted, etc., as follows:

SECTION 1. Petitions under the provisions of section fourteen of chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five, or of section one of chapter four hundred and forty-five of the acts of the year eighteen hundred and ninety-seven, and acts in amendment thereof or in addition thereto, for the determination of damages for the taking of real estate may be filed, as provided by law, within two years after the actual taking by right of eminent domain of such real estate or of any interest therein, and petitions for the determination of all other damage provided for in said acts may be filed on or before the first day of July in the year nineteen hundred and one. Time within which certain petitions for damages may be filed extended.

SECTION 2. This act shall take effect upon its passage.
[Approved May 6, 1899.]

[Chapter 349 of the Acts of the Year 1899.]

AN ACT RELATIVE TO SUPPLYING CERTAIN CITIES AND TOWNS WITH WATER FROM THE METROPOLITAN WATER SYSTEM.

Be it enacted, etc., as follows:

SECTION 1. Section three of chapter four hundred and eighty-eight of the acts of the year eighteen hundred and ninety-five, as amended by chapter three hundred and ninety-two of the acts of the year eighteen hundred and ninety-eight, is hereby amended 1895, 488, § 3, etc., amended.

To construct,
etc., a system of
metropolitan
water works.

Metropolitan
Water District.

Certain cities
and towns may
be admitted,
etc.

Proviso.

Distribution of
payments of
money, furnish-
ing of water, etc.

by inserting after the word "town", in the thirtieth line, the words:—last referred to,—so as to read as follows:—*Section 3.* Said board, acting for the Commonwealth, shall construct, maintain and operate a system of metropolitan water works substantially in accordance with the plans and recommendations of the state board of health, contained in their report to the legislature of the year eighteen hundred and ninety-five, and shall provide thereby a sufficient supply of pure water for the following named cities and towns, and the inhabitants thereof, to wit:—The cities of Boston, Chelsea, Everett, Malden, Medford, Newton and Somerville, and the towns of Belmont, Hyde Park, Melrose, Revere, Watertown and Winthrop, which cities and towns shall constitute the Metropolitan Water District; shall secure and protect the purity of said water; shall on application furnish water to any city or town aforesaid that at the time of application owns its water pipe system; shall on application admit any other city or town, any part of which is within ten miles of the state house, into said water district, and furnish water to the same on the terms prescribed by this act for the cities and towns aforesaid, and on such payment of money as said board may determine; shall on application furnish water to any water company owning the water pipe system in any town within said ten miles, on such water company assuming the assessments of the town, if any, and making such payment of money as said board may determine; and may from time to time furnish water to any other city, town or water company, on such payment of money as said board may determine: *provided*, that any such city or town last referred to shall first have acquired the works of any water company therein situated, constructed for the purpose of supplying said city or town or its inhabitants with water. All payments of money aforesaid shall be distributed to the cities and towns in said district in proportion to the total amount of the annual assessments theretofore paid by them respectively. Said board shall furnish said water to the city, town or company, by delivering the same into a main water pipe, reservoir or tank of the city, town or company, under sufficient pressure for use without local pumping, unless delivered in some other manner by mutual agreement between the parties interested; and shall have the direction and control of the connections between the metropolitan and local systems. Said board may utilize the fall of water at any dam under their charge, and may thereby produce power or electricity, and may transmit such power or electricity by pipes, wires, or other suitable

means, and sell the same, or the right to use such water, by written or other contract, to run for a term not exceeding fifteen years. Any person or corporation authorized by said board shall have all the powers relating to the production, sale and transmission of power and electricity given by this act to said board.

SECTION 2. This act shall take effect upon its passage.
[*Approved May 9, 1899.*

[Chapter 480 of the Acts of the Year 1899.]

AN ACT RELATIVE TO DAMAGES OCCASIONED BY THE CONSTRUCTION OF BASINS OR RESERVOIRS FOR WATER SUPPLY IN THE TOWN OF ASHLAND.

Be it enacted, etc., as follows :

SECTION 1. The treasurer of the Commonwealth shall pay as a part of the expenses of the metropolitan water works, to the town of Ashland so long as said town remains a municipality, the sum of twenty-two hundred dollars in the month of September in the year eighteen hundred and ninety-nine, and the like sum in the same month in each succeeding year until ten years after the reservoirs or basins situated in said town of Ashland cease to be a part of the metropolitan water system ; but shall pay no tax and make no other payment to said town on account of any property held by said water board for the purpose of a water supply.

Certain sums to be paid to town of Ashland.

SECTION 2. This act shall take effect upon its passage.
[*Approved June 3, 1899.*

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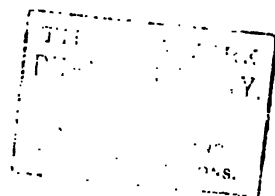
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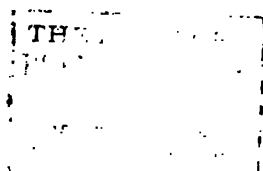
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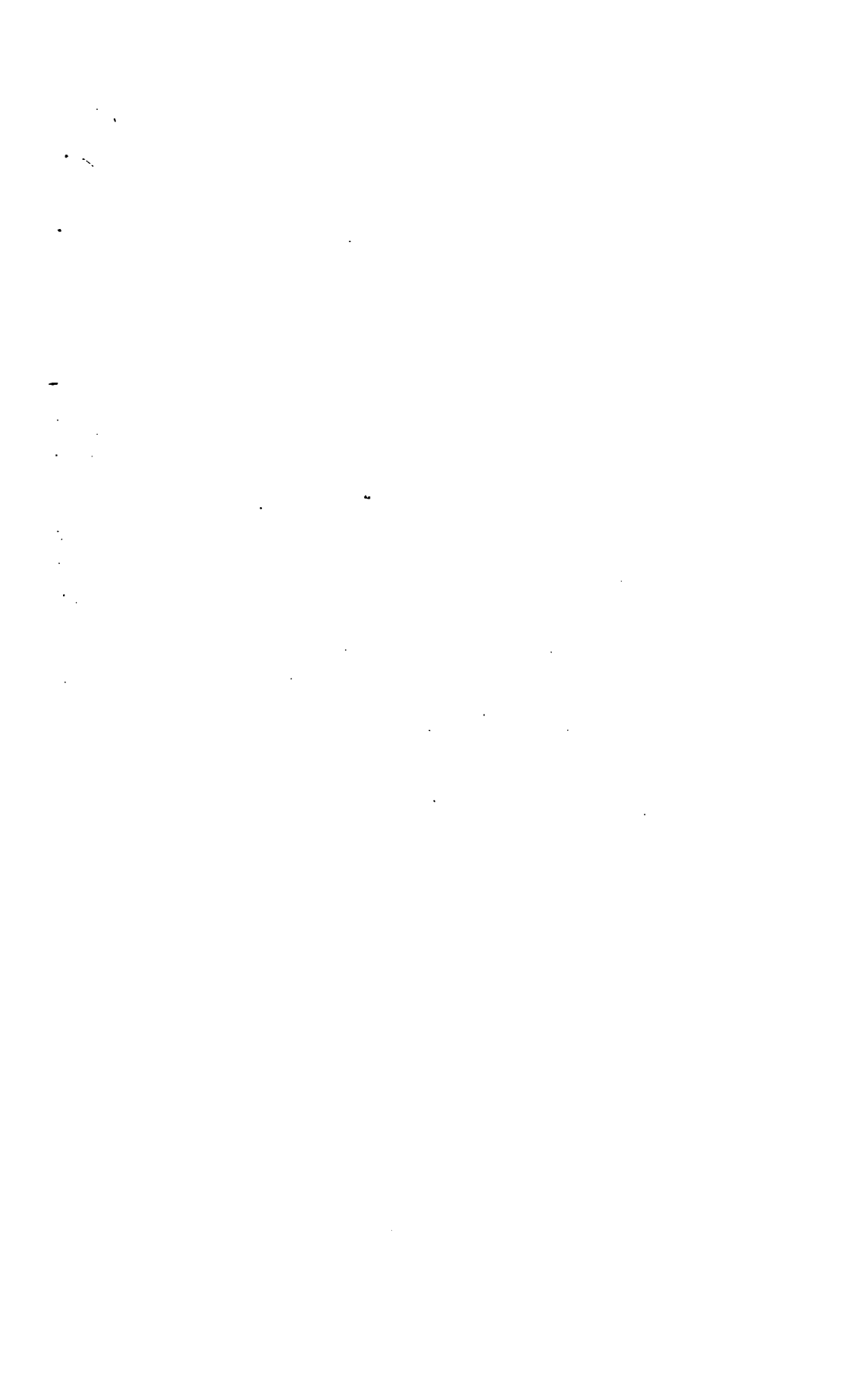
W.**WATER BOARD.**

See Metropolitan Water Board.





1. The first part of the paper is devoted to a discussion of the general principles of the theory of the structure of the human brain, and the second part to a description of the results of the experiments.



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